MERCURY
MerCruiser

SERVICE MANUAL

SUPPLEMENT TO NUMBER 27

MARINE ENGINES
V-8 DIESEL

D7.3L D-Tronic - Serial Number OLO50050 and Above
D7.3L D-Tronic LD - Serial Number OLO50050 and Above

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Notice

Throughout this publication, “Dangers,” “Warnings” and “Cautions” (accompanied by the International HAZARD Symbol ⚠) are used to alert the mechanic to special instructions concerning a particular service or operation that may be hazardous if performed incorrectly or carelessly. **OBSERVE THEM CAREFULLY!**

These “Safety Alerts” alone cannot eliminate the hazards that they signal. Strict compliance to these special instructions when performing the service, plus “Common Sense” operation, are major accident prevention measures.

⚠ DANGER

DANGER - Immediate hazards which WILL result in severe personal injury or death.

⚠ WARNING

WARNING - Hazards or unsafe practices which COULD result in severe personal injury or death.

⚠ CAUTION

Hazards or unsafe practices which could result in minor personal injury or product or property damage.

Notice to Users of This Manual

This service manual supplement has been written and published by the Service Department of Mercury Marine to aid our dealers' mechanics and company service personnel when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures of these products or similar products manufactured and marketed by Mercury Marine and that they have been trained in the recommended servicing procedures of these products including the use of mechanics' common hand tools and the special Mercury Marine or recommended tools from other suppliers.

We could not possibly know of and advise the service trade of all conceivable procedures by which a service might be performed and of the possible hazards and/or results of each method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a service procedure and/or tool that is not recommended by the manufacturer, first must completely satisfy himself that neither his nor the products safety will be endangered by the service procedure selected.

It should be kept in mind, while working on the product, that the electrical system and injection system are capable of violent and damaging short circuits or severe electrical shocks. When performing any work where electrical terminals could possibly be grounded or touched by the mechanic, the battery cables should be disconnected at the battery.

Any time the intake or exhaust openings are exposed during service they should be covered to protect against accidental entrance of foreign material that could enter the cylinders and cause extensive internal damage when the engine is started.

During any maintenance procedure replacement fasteners must have the same measurements and strength as those removed. Numbers on the heads of the metric bolts and on the surfaces of metric nuts indicate their strength. American bolts use radial lines for this purpose, while most American nuts do not have strength markings. Mismatched or incorrect fasteners can result in damage or malfunction, or possibly personal injury. Therefore, fasteners removed should be saved for reuse in the same locations whenever possible. Where the fasteners are not satisfactory for re-use, care should be taken to select a replacement that matches the original.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. As required, revisions to this manual will be sent to all dealers contracted by us to sell and/or service these products.

We reserve the right to make changes to this manual without prior notification.

Refer to dealer service bulletins for other pertinent information concerning the products described in this manual.

Engine Mechanical Components

Many of the engine mechanical components are designed for marine applications. Unlike automotive engines, marine engines are subjected to extended periods of heavy load and wide-open-throttle operation and, therefore, require heavy-duty components. Special marine engine parts have design and manufacturing specifications which are required to provide long life and dependable performance. Marine engine parts also must be able to resist the corrosive action of salt or brackish water that will rust or corrode standard automotive parts within a short period of time.

Failure to use recommended Quicksilver service replacement parts can result in poor engine performance and/or durability, rapid corrosion of parts subjected to salt water and possibly complete failure of the engine.

Use of parts other than recommended service replacement parts, will void the warranty on those parts which are damaged as a result of the use of other than recommended replacement parts.

Replacement Parts

⚠ WARNING

Electrical, ignition and fuel system components on MerCruiser Engines and Stern Drives are designed and manufactured to comply with U.S. Coast Guard Rules and Regulations to minimize risks of fire or explosion.

Use of replacement electrical, ignition or fuel system components, which do not comply to these rules and regulations, could result in a fire or explosion hazard and should be avoided.

When servicing the electrical, ignition and fuel systems, it is extremely important that all components are properly installed and tightened. If not, any electrical or ignition component opening would permit sparks to ignite fuel vapors from fuel system leaks, if they existed.

Cleanliness and Care of Product

A marine power product is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in the ten thousands of an inch/mm. When any product component is serviced, care and cleanliness are important. Throughout this manual, it should be understood that proper cleaning and protection of machined surfaces and friction areas is a part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Personnel should not work on or under an engine that is suspended. Engines should be attached to work stands, or lowered to ground as soon as possible.

Whenever components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

Models Covered in This Manual

Model	Serial Number	Model Year
MCM D7.3L D-Tronic	OLO50050 and Above	1998 -
MCM D7.3L D-Tronic LD	OLO50050 and Above	1998 -

Service Manual Supplement Outline

Section 1 - IMPORTANT INFORMATION
Section 3 - ENGINE
Section 4 - ELECTRICAL SYSTEMS
Section 5 - FUEL SYSTEM

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Service Manual Supplement Outline

Section 1 - IMPORTANT INFORMATION
Section 3 - ENGINE
Section 4 - ELECTRICAL SYSTEMS
Section 5 - FUEL SYSTEM

Section 1A - General Information
Section 1B - Maintenance and Specifications
Section 3A - Mechanical
Section 4E - Wiring Diagrams
Section 5A - Engine Control System Overview
Section 5B - Mechanical Diagnostics
Section 5C - Electronic Control System Diagnostics
Section 5D - Diagnostic Tool Use
Section 5E - Fuel System Glossary

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IMPORTANT INFORMATION

Section 1A - General Information

1 A

Table of Contents

General Information 1A-3

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INDEX

General Information

The following sections of supplemental information to SERVICE MANUAL NUMBER 27 have been prepared to assist in the identification and servicing of MerCruiser direct injected V-8 diesel engines equipped with the latest D-Tronic fuel injection system.

On previous direct-injected V-8 diesel engines the engine control and injection system was commonly referred to as a “3-Box” system. The three “boxes,” or electronic control modules, were the Vessel Personality Module (VPM), Injector Driver Module (IDM) and Electronic Control Module (ECM) . The latest system is referred to as a “1-Box” engine control system because there is only one electronic control module – the ECM. Although there are differences in the actual components and the on-board diagnostic capabilities between the control systems of the 3-Box and 1-Box engines, there are also shared or similar components and capabilities.

This supplement is intended to be used in conjunction with SERVICE MANUAL NUMBER 27, and not in place of the manual. The scope of this supplement is to highlight new or different specifications, components and procedural information as they pertain to the V-8 diesel D-Tronic engines equipped with a single (1-Box) ECM versus previous engines.

An understanding of the material contained herein and in subsequent publications issued when necessary will assist service personnel in properly maintaining the MerCruiser engine and control systems at the level of quality to which they are built.

IMPORTANT INFORMATION

Section 1B - Maintenance and Specifications

Table of Contents

Power Package Views 1B-3
Front 1B-3
Port (Left) Side 1B-4
Maintenance Schedules 1B-5
Scheduled Maintenance To Be Performed By Owner/Operator 1B-5
Scheduled Maintenance That Should Be Performed By A Dealer 1B-6
Specifications 1B-8
Anti-Freeze/Coolant 1B-8
Crankcase Oil 1B-9
Capacities 1B-9
Engine 1B-10

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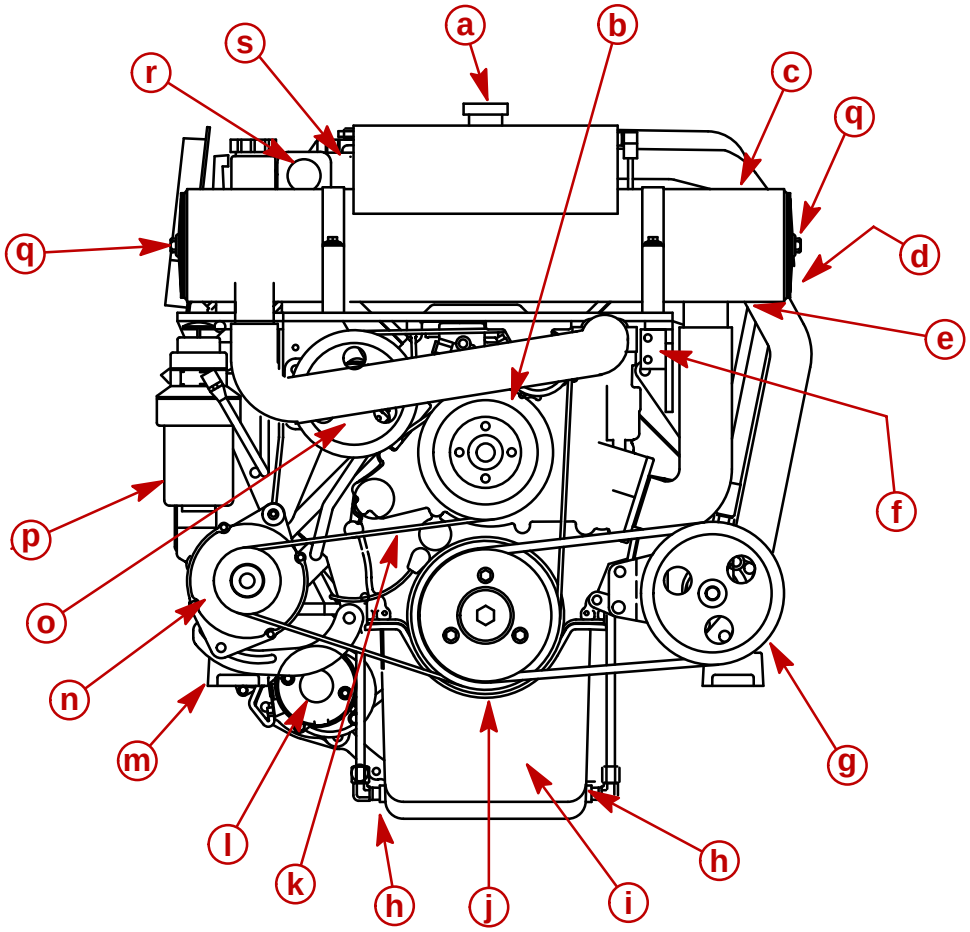
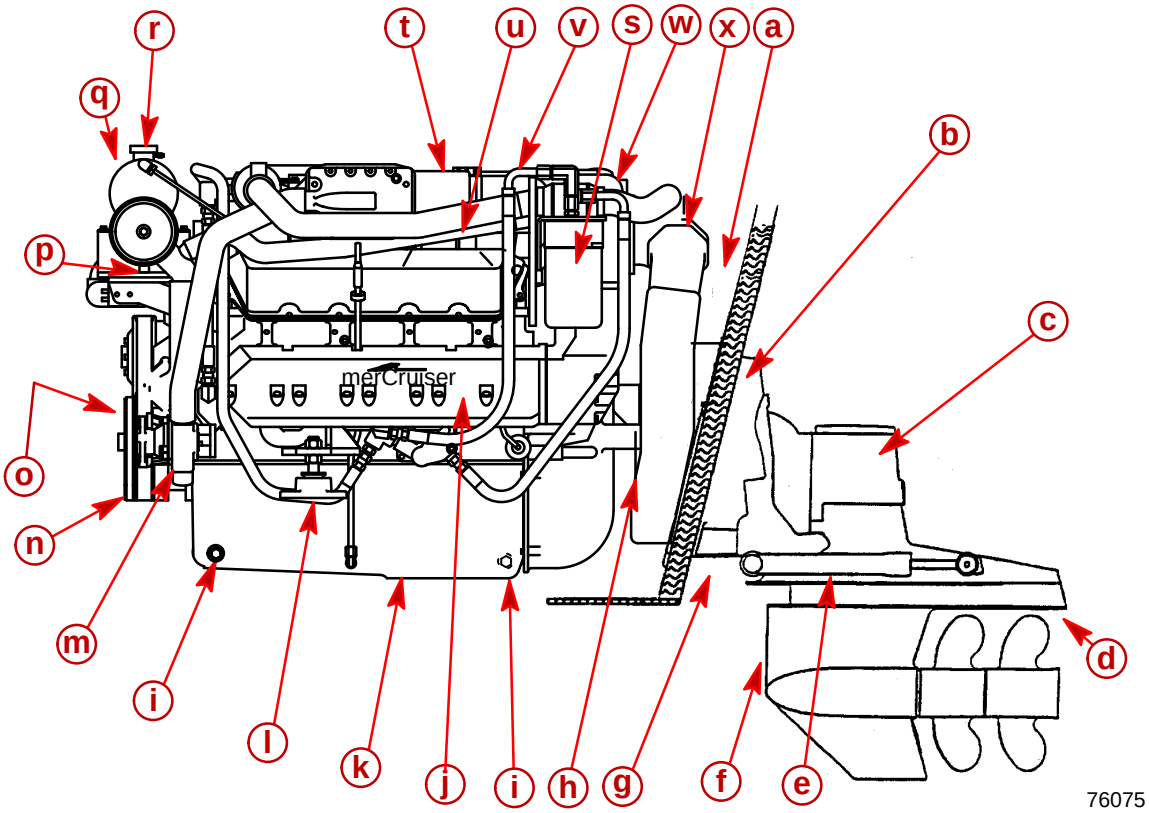
Power Package Views

Front



a - Heat Exchanger/Coolant Tank Cap
b - Engine Water Circulating Pump and Pulley
c - Heat Exchanger/Coolant Tank
d - Engine Oil Dipstick
e - Sacrificial Anode (On Heat Exchanger)
f - Fuel Inlet and Return Line Fittings
g - Seawater Pump and Pulley
h - Oil Pan Drain Plug
i - Oil Pan
j - Crankshaft Pulley
k - Engine Water Circulating Pump Belt
l - Starter
m - Front Engine Mount (Starboard)
n - Alternator
o - Power Steering Pump and Pulley
p - Water Separating Fuel Filter
q - Heat Exchanger End Cap (For Draining Seawater Cooling Water)
r - Engine Oil Cooler
s - Sacrificial Anode (On Engine Oil Cooler)

Port (Left) Side



a - Steering System
b - Transom Assembly
c - Sterndrive Unit
d - Antiventilation Plate
e - Power Trim Cylinder
f - Speedometer Pitot Tube
g - MerCathode Electrode
h - Rear Engine Mount
i - Oil Pan Drain Plug
j - Exhaust Manifold
k - Oil Pan
l - Front Engine Mount
m - Seawater Pump and Pulley
n - Crankshaft Pulley
o - Alternator
p - Sacrificial Anode (On Heat Exchanger)
q - Heat Exchanger/Coolant Tank
r - Heat Exchanger/Coolant Tank Cap
s - Engine Oil Filter
t - Aftercooler
u - Engine Oil Fill Cap (Port)
v - Air Filter
w - Turbocharger
x - Exhaust Elbow

CD501

Maintenance Schedules

Scheduled Maintenance To Be Performed By Owner/Operator

NOTE: *Only perform maintenance which applies to your particular power package.*

Task	Interval
Engine Crankcase Oil - Check level.	Before Use
Fuel Filter - Drain	
Seawater Strainer - Check / Clean.	Before Use / As Required
Closed Cooling Coolant - Check level.	Weekly
Power Steering Fluid - Check level.	
Sterndrive Unit Oil - Check level.	
Battery - Check level and inspect for damage.	
Power Trim Pump Oil - Check level.	
Drive Unit Alloy Anodes - Inspect for erosion.	
Gear Housing Water Pickups - Check for marine growth or debris.	
Air Filter - Clean.	Every 50 hours of operation or as conditions require.
Drive Belts (All) - Inspect condition and check tension.	Every 100 hours of operation or 120 days, whichever occurs first.
Fuel Filter - Replace.	
Propeller Shaft - Lubricate.	**Saltwater Use**: Every 50 hours of operation or 60 days, whichever occurs first. **Freshwater Use:** Every 100 hours of operation or 120 days, whichever occurs first.
Power Package Exterior Surfaces - Spray with rust preventative.	
Sacrificial Anode (in intercooler) – Check and replace when over 50% eroded.	Once a year
Sacrificial Anode (in heat exchanger) – Check and replace when over 50% eroded.	
Power Package Exterior Surfaces - Clean and paint.	
Cooling System - Flush seawater section.	**Saltwater Use:** After every use.

CD563

Scheduled Maintenance That Should Be Performed By A Dealer

NOTE: *Only perform maintenance which applies to your particular power package.*

Task	Interval
Seawater Pickup Pump - Disassemble and inspect.	Whenever insufficient seawater flow is suspected, if operating temperature exceeds normal range.
Crankcase Oil and Filter - Change.	After 20-hour break-in period, then, for **Pleasure Craft Use:** every 100 hours of use or 120 days, whichever occurs first; and for **Light Duty Craft Use:** every 50 hours of use or 60 days, whichever occurs first.
Flame Arrestor and Crankcase Ventilation Hose - Clean and inspect.	End of first boating season and thereafter, every 100 hours of operation or once yearly, whichever occurs first.
Sterndrive Unit Oil - Change.	
Gimbal Ring Clamping Screws - Retorque to 40 lb. ft. (54 N·m).	
Rear Engine Mounts - Check, torque to 30-40 lb-ft (47-54 Nm).	
Gimbal Bearing - Lubricate.	
Cooling System - Clean and inspect.	
Engine Alignment - Check.	
Engine Coupling Universal Joint Shaft Splines - Lubricate.	
Steering System - Lubricate and inspect for loose, damaged or missing parts.	
Electrical System - Check for loose or damaged wiring.	
Closed Cooling System Pressure Cap - Clean, inspect and test.	
Cooling System Hoses and Clamps - Inspect for damage and deterioration. Check clamps for tightness.	
Continuity Circuit - Check components for loose connections, broken or frayed wires.	
Shift and Throttle Cable, and Linkage - Lubricate and inspect for loose, damaged or missing parts.	
Engine Exhaust System - Inspect externally for damage, deterioration and restrictions. Check for tightness.	
Steering Head and Remote Control - Inspect and lubricate.	

CD534

Scheduled Maintenance That Should Be Performed By A Dealer (Continued)

NOTE: *Only perform maintenance which applies to your particular power package.*

Task	Interval
Fuel Filter(s) - Replace.	Once a year.
Quicksilver Mercathode System - Test output.	
Closed Cooling Coolant - Test for alkalinity.	
Heat Exchanger - Clean seawater section.	
Drive Unit Bellows and Clamps - Inspect.	
Universal Joint Cross Bearings- Inspect.	End of first boating season and thereafter, every 200 hours of operation or once yearly, whichever occurs first.
Clean Aftercooler Core.	Every 500 hours of operation
Clean Fuel Tank.	Every 1000 hours of operation
Closed Cooling System Anti-Freeze / Coolant - Replace.	Every two years or 200 hours of operation, whichever occurs first.

Specifications

CD535

Anti-Freeze / Coolant

⚠ CAUTION

Alcohol or Methanol base antifreeze or plain water are not recommended for use in closed cooling section of cooling system at any time.

Because diesel engines are high compression engines and related higher engine operating temperatures are created, the closed cooling system and engine, including related cooling passages must remain as clean as possible to provide adequate engine cooling. This can only be assured by using the proper anti-freeze, water, additives and inhibitors. It is recommended that the closed cooled section of the cooling system be filled with a low, or no, silicate formula of ethylene glycol antifreeze in solution with deionized water. A low silicate formula prevents antifreeze separation which causes a silicate gelatin to form. This gelatin will block engine and heat exchanger passages causing engine overheating.

The coolant, if not premixed, should be mixed before being added to the closed cooling system using a proper anti-freeze together with deionized water. Common tap water or softened water contains unwanted minerals which can leave large deposits in the system that restrict the cooling system efficiency. In addition, additives and inhibitors introduced into acceptable coolant solutions will form a protective film on internal passages and provide protection against internal cooling system erosion.

The closed cooling section should be kept filled year-round with an acceptable anti-freeze/coolant solution. Do not drain closed cooled section for storage, as this will promote rusting of internal surfaces. If engine will be exposed to freezing temperatures, make sure that closed cooled section is filled with a properly mixed antifreeze/coolant solution, to protect engine and closed cooling system to lowest temperature to which they will be exposed.

IMPORTANT: The anti-freeze/coolant used in these marine engines must be a low (or no) silicate ethylene glycol, containing special additives, and deionized, purified water. Using other types of engine coolant may cause fouling of the heat exchangers and overheating of the engine. Do not combine different types of coolants without knowing that they are compatible. Refer to the coolant manufacturer's instructions.

Some acceptable types of anti-freeze/coolants are listed in the following table. Refer to "Maintenance Schedules" for respective change intervals.

Quicksilver Premixed Marine Engine Coolant	92-813054A2
Fleetguard Complete (with DCA4 Additive)	Obtain Locally

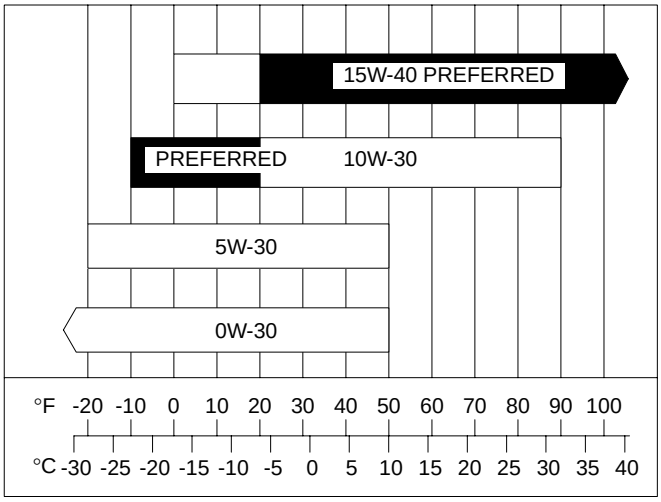
CD556

Crankcase Oil

To help obtain optimum engine performance and to provide maximum protection, the engine requires engine oil with a rating of HD-SAE-API, CG-4.

For all temperature operation use 15W-40 oil.

OIL VISCOSITY RECOMMENDATIONS



SAE Viscosity Grades / Expected Temperature Range

CD597

Capacities

NOTE: *All measurements are given in US Quarts (Liters).*

Item		Specification - MCM (Sterndrive) D7.3L D-Tronic and D7.3L D-Tronic LD
Total Oil-Filling Capacity[1]		16.5 (15.6)
Oil Drainage	from oil pan	14.5 (13.7)
	from oil filter	1 (1)
	from oil cooler	1 (1)
Drive Unit Oil Capacity (With Gear Lube Monitor)[1]	Bravo Two	3.2 (3)
	Bravo Three	3 (2.9)
Closed Cooling System		26 (24-1/2)

[1] Always use dipstick to determine exact quantity of oil or fluid required.

CD557

Engine

Description		Specification - MCM (Sterndrive)	
		D7.3L D-Tronic	D7.3L D-Tronic LD
Crankshaft Horsepower (Kilowatts) [1]		300 (223)	260 (195)
Propeller Shaft Horsepower (Kilowatts) [1]		270 (202)	230 (170)
Engine Type		V-8 Cylinder Diesel	
Displacement		444 cu. in. (7.3L)	
Firing Order		1-2-7-3-4-5-6-8	
Bore		4.11 in. (104.39 mm)	
Stroke		4.18 in. (106.20 mm)	
Compression Ratio		15:1	
Valve Clearance - Intake / Exhaust		Non-Adjustable (Hydraulic)	
Maximum Pressure Difference Between Cylinders		75 PSI (517 kPa)	
Maximum High Idle No Load rpm		3950	3750
Governed RPM Setting (Begins At:)		3850	3650
Rated RPM at Wide-Open-Throttle		3600-3800	3400-3600
Low Idle RPM		625 ± 25	
Oil Pressure:	750 rpm	10 PSI [0.7 bar (69 kPa)] Minimum	
	3600 rpm	40-70 PSI [2.8 - 4.8 bar (276-482 kPa)]	
Oil Temperature		190° - 250° F (88° - 121° C)	
Thermostat:	Water:	170° F (77° C)	
Coolant Temperature		170° - 210° F (77° - 99° C)	
Electrical System		12-volt Negative (–) Ground	
Alternator Rating		949W, 14.6v, 65A	
Recommended Battery Rating		1500 cca or 300 Ah	
Starter		12v, 2.4 kW	

[1] Power rated in accordance with NMMA Procedure - ISO 3046 (Technically Identical to ICOMIA 28-83).

ENGINE

Section 3A - Mechanical

Table of Contents

General Information	3A-3	Cylinder Head Gasket Installation	3A-5
Torque Specifications	3A-4	Oil Filter By-Pass Valve	3A-5
Special Tools	3A-4	High Pressure Hoses	3A-6
Lubricants/Sealants/Adhesives	3A-4	Front Cover And Water Pump	3A-7
Tandem Lift Pump	3A-5		

3 A

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General Information

Unless stated otherwise, the information contained in this SECTION provides new or different specifications, components and procedural information as they pertain to ALL the V-8 diesel engines equipped with D-Tronic system control, including previous “3-Box” engines.

Torque Specifications

IMPORTANT: Fasteners not listed should be tightened securely.

Item / Fastener Location		lb-in.	lb-ft	Nm
Fuel Injector Hold Down Clamp Mounting Bolt		120		13.6
Fuel Injector Hold Down Clamp Shoulder Bolt		120		13.6
Connecting Rod Cap	First Step		52	108
	Final Torque		80	108
Torsional Damper			212	287

Special Tools

OTC SPECIAL TOOLS		
Can be ordered from:	OTC Division 655 Eisenhower Drive Owatonna, MN 55060 Phone: 1-800-533-5338 or 1-800-533-0492 Fax: 1-800-283-8665	
Description		**Part Number**
Orificed Restrictor Adapter [1]		ZTSE4284
ICP Sensor Breakout Harness [1]		ZTSE4347
Software Cartridge (NAVPAK) [1]		
Breakout Box [1]		ZTSE4445
9-Pin Injector Harness/Revised [1]		ZTSE4458
Oil Pressure Test Kit [1] Consists of:		ZTSE4454
	Hose Release Tool	ZTSE4459
	High Pressure Hose ICP Adapter	ZTSE4450
	High Pressure Hose Block Off Adapter	ZTSE4451

[1] : For 1-Box ECM Engines.

Lubricants/Sealants/Adhesives

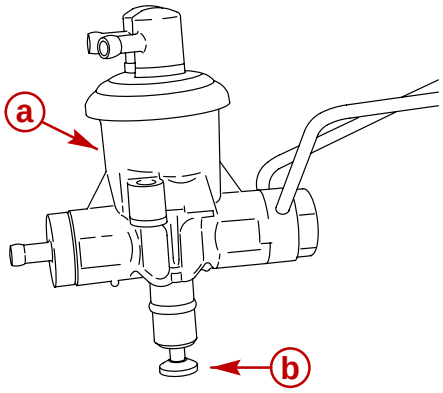
Description	Part Number
Wacker - T442® Sealant	92-862258

Tandem Lift Pump

⚠ CAUTION

Avoid fuel leakage. Tappet shaft is internally sealed. If tappet falls out of tandem lift pump, carefully insert tappet into pump to avoid damaging internal seals. Damaged seals will leak fuel into engine causing product performance problems or product damage.

Retrieve tappet from pump bore in crankcase if required. CAREFULLY insert into base of tandem pump to avoid damaging internal tappet shaft seals.



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a - Tandem Lift Pump
b - Tappet

Cylinder Head Gasket Installation

Procedures regarding the cylinder head gaskets remain the same as in SERVICE MANUAL NUMBER 27 with the following exceptions for the “1-Box” ECM engines:

- The gasket is not common between banks. Two gaskets with separate part numbers are needed - one port and one starboard.
- New gaskets have a BLUE colored strip and the word “UP” on the top-facing surface of the gasket.

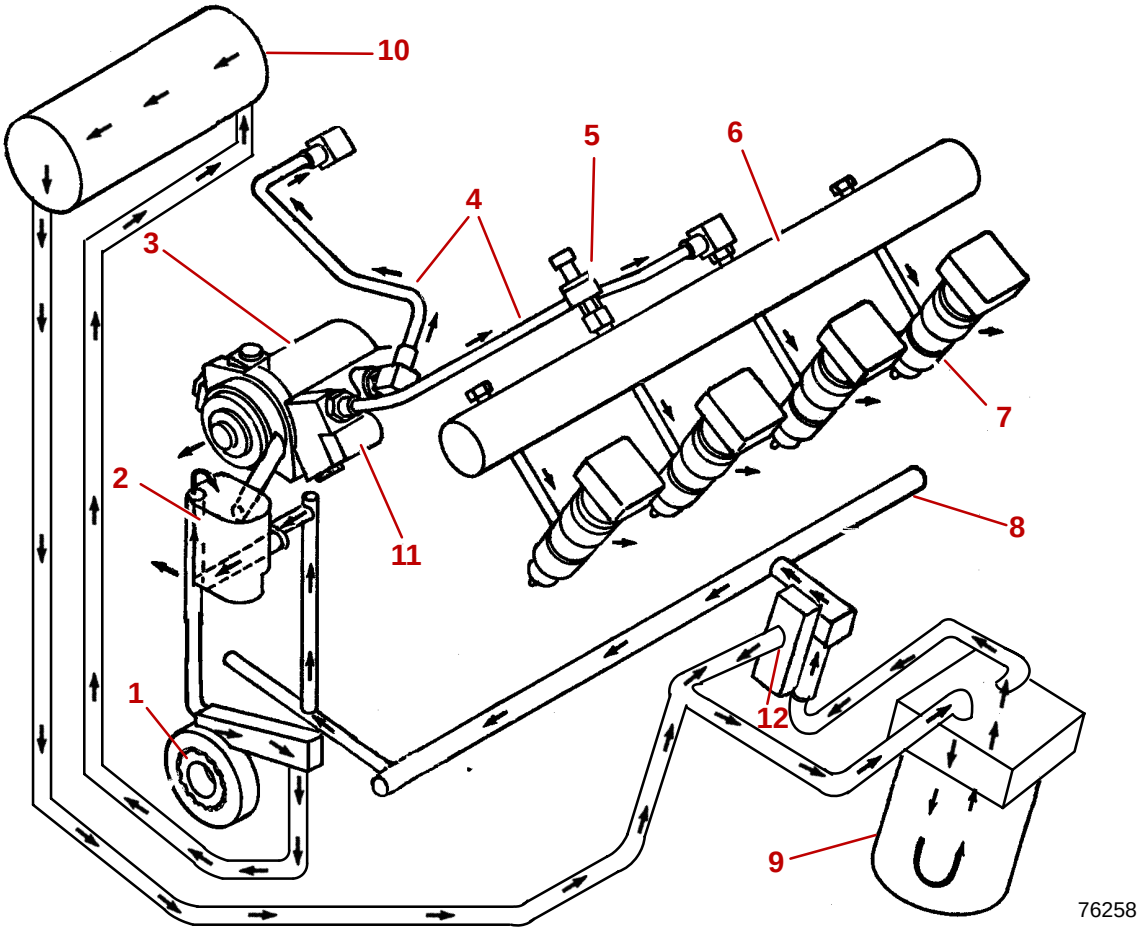
Oil Filter By-Pass Valve

New oil filter by-pass valve located in the oil pressure regulator flange is retained by a C-clip, not “staked” in as on earlier engines.

High Pressure Hoses

Beginning on the 1-Box ECM D-Tronic engines the high pressure hoses from the ICP Regulator to the High Pressure Rails have special quick-connect hose ends and fittings. A special Hose Release Tool is used to separate the hose from the fittings. This tool is in the Oil Pressure Test Kit or can be ordered separately. The tool must be used for proper release.

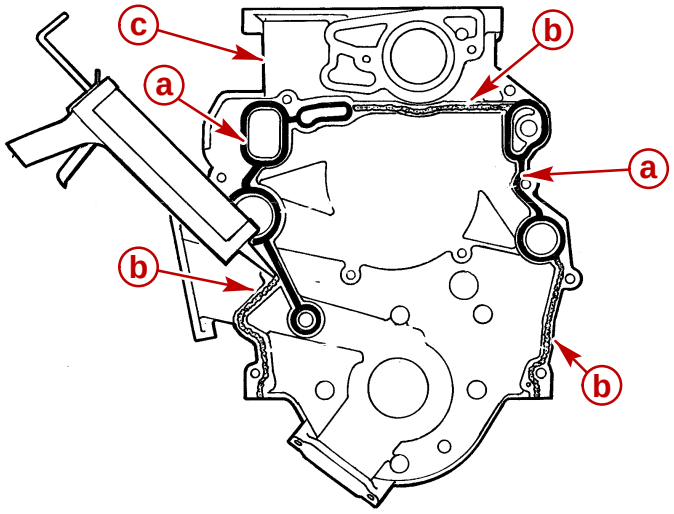
After reattaching the special quick connections always test ("tug-test") the connection fittings to be certain they are fully engaged prior to starting the engine.



1 - Oil Pump
2 - Reservoir (Located On Top of Front Cover)
3 - High Pressure Pump
4 - High Pressure Hoses With Special Quick Connection Ends
5 - Injection Control Pressure Sensor
6 - Cylinder Head High Pressure Rail
7 - Injector (8)
8 - Gallery (Crankcase)
9 - Oil Filter
10 - Oil Cooler
11 - Injection Control Pressure Regulator
12 - Oil Filter By-Pass Valve / Oil Pressure Regulator

Front Cover And Water Pump

Position two new gaskets and apply Wacker T-442® in remaining sealing grooves on front cover.



EG1937

a - New Gaskets
b - Wacker T-442® Locations
c - Front Cover

ELECTRICAL SYSTEMS

Section 4E - Wiring Diagrams

Table of Contents

Wire Color Abbreviations 4E-3
ECM Harness Schematic 4E-4
Connectors 4E-5
Terminals 4E-5
ECM Harness Assembly 4E-6
Terminal and Connector Locations 4E-6
Connectors 4E-7
Terminals 4E-7
Engine Harness Schematic 4E-8
Engine Harness Assembly 4E-9
Instrument Panel Wiring Diagrams 4E-10
Primary Station Instrumentation (Single Station) 4E-10
Primary Station Instrumentation (With Relay for Second Station Installed) . . 4E-12
Second Station Instrumentation 4E-14
Circuit Breakers and Power Circuits . . 4E-16

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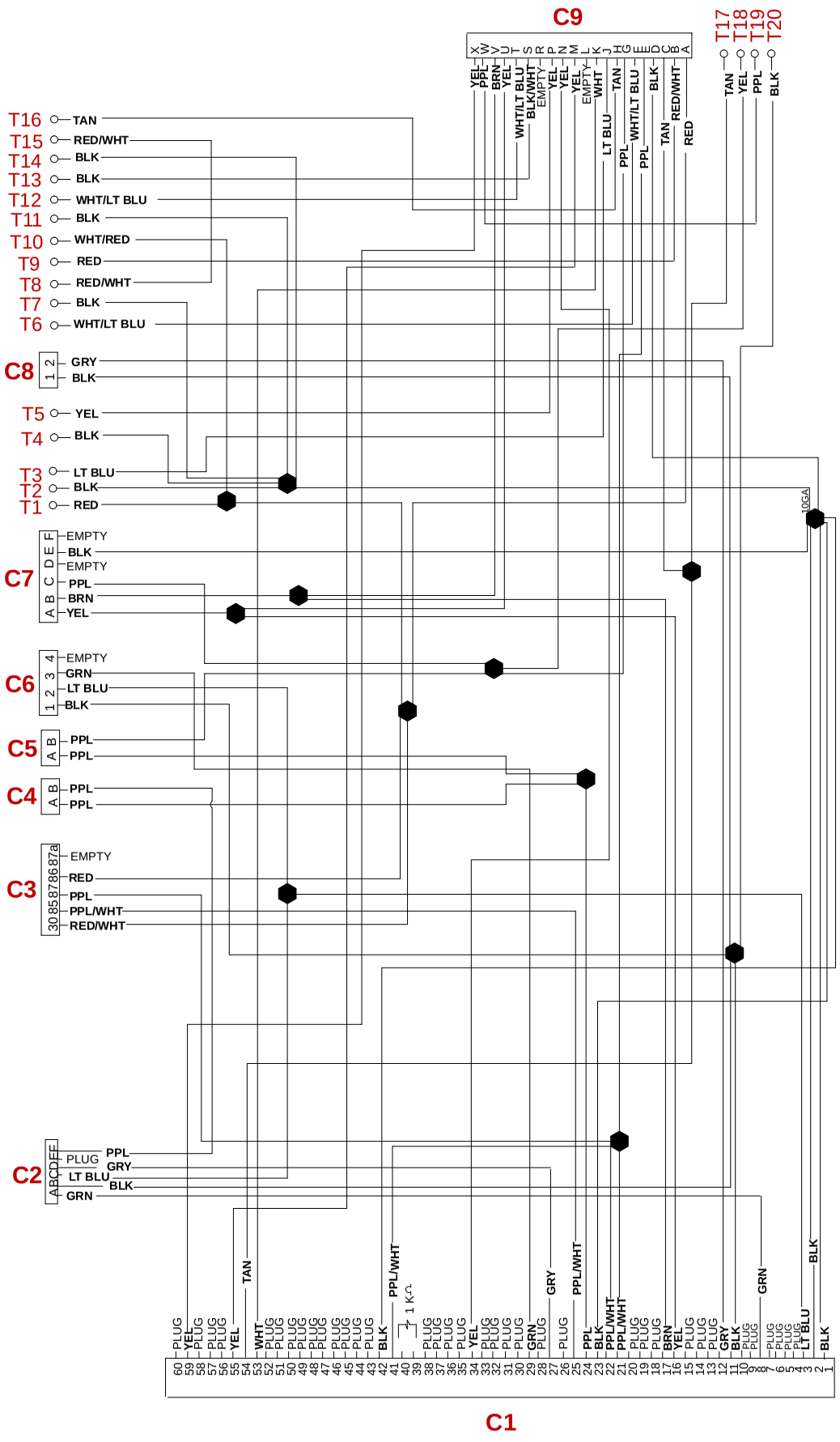
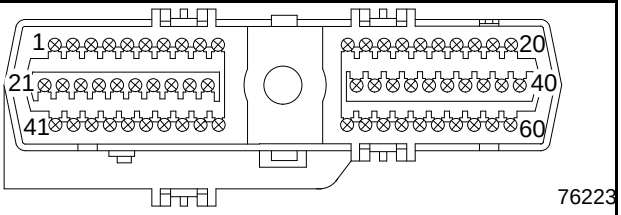
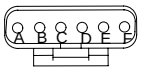
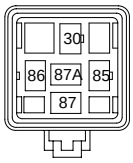
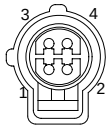
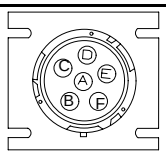
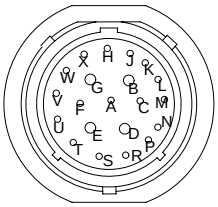
Wire Color Abbreviations

BLK	Black
BLU	Blue
BRN	Brown
GRY	Gray
GRN	Green
ORN	Orange
PNK	Pink
PUR or PPL	Purple
RED	Red
TAN	Tan
WHT	White
YEL	Yellow
LIT or LT	Light
DRK	Dark

ECM Harness Schematic



Connectors

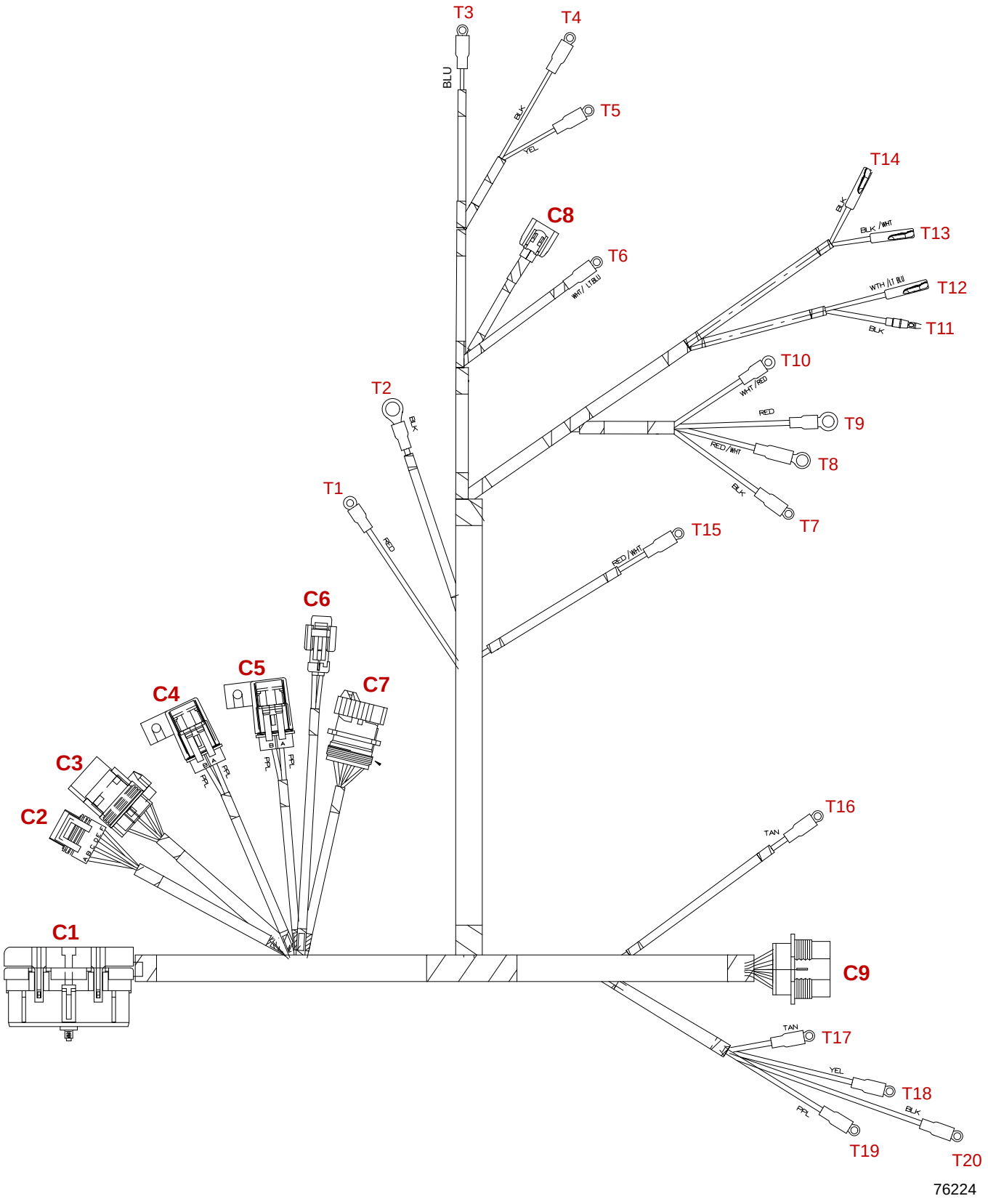
Number	Description	Illustration
C1	60 Way Connector - ECM	
C2	6 Way Connector - APS/IVS Switch	
C3	Relay Connector - ECM Relay	
C4	2 Way Connector - Fuse Holder	
C5	2 Way Connector - Fuse Holder	
C6	4 Way Connector - BARO Sensor	
C7	6 Way Connector - ATA Diagnostic Connector	
C8	Two Way Connector - IAT Sensor	
C9	21 Way Connector - Instrument Harness Connector	

Terminals

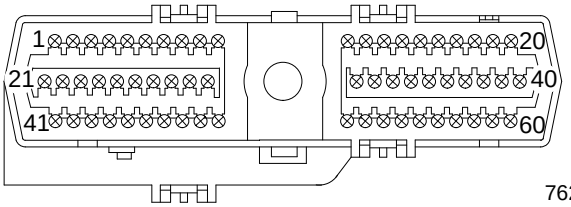
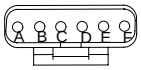
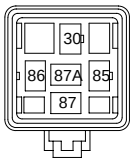
Number	Wire Color - Location	Number	Description - Location
T1	RED - 30 Amp Breaker	T11	BLK - Trim Sender
T2	BLK - Engine Ground (–)	T12	WHT/LT BLU - Trim Sender
T3	BLU - EOP Sender	T13	BLK/WHT - Gear Lube Monitor Alarm
T4	BLK - Tachometer Pickup	T14	BLK - Gear Lube Monitor Alarm
T5	YEL - Tachometer Pickup	T15	RED/WHT - Starter Relay (Slave Solenoid)
T6	WHT/LT BLU - Oil Temperature Alarm	T16	TAN - Coolant Temperature Sender
T7	BLK - Starter Relay (Slave Solenoid)	T17	TAN - Coolant Alarm
T8	RED/WHT - Starter Relay (Slave Solenoid)	T18	YEL - Alternator Terminal, “EXC”
T9	RED - Starter Relay (Slave Solenoid)	T19	PPL - Alternator Terminal, “L2”
T10	WHT/RED - Starter Relay (Slave Solenoid)	T20	BLK - Alternator Terminal, “E”

ECM Harness Assembly

Terminal and Connector Locations



Connectors

Number	Description	Illustration
C1	60 Way Connector - ECM	
C2	6 Way Connector - APS/IVS Switch	
C3	Relay Connector - ECM Relay	
C4	2 Way Connector - Fuse Holder	
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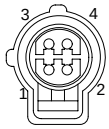
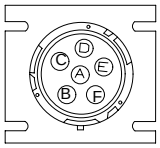
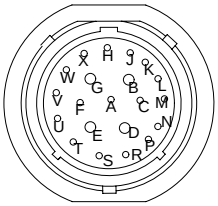
C6	4 Way Connector - BARO Sensor	
C7	6 Way Connector - ATA Data Link (Diagnostic Connector)	
C8	Two Way Connector - IAT Sensor	
C9	21 Way Connector - Instrument Harness Connector	

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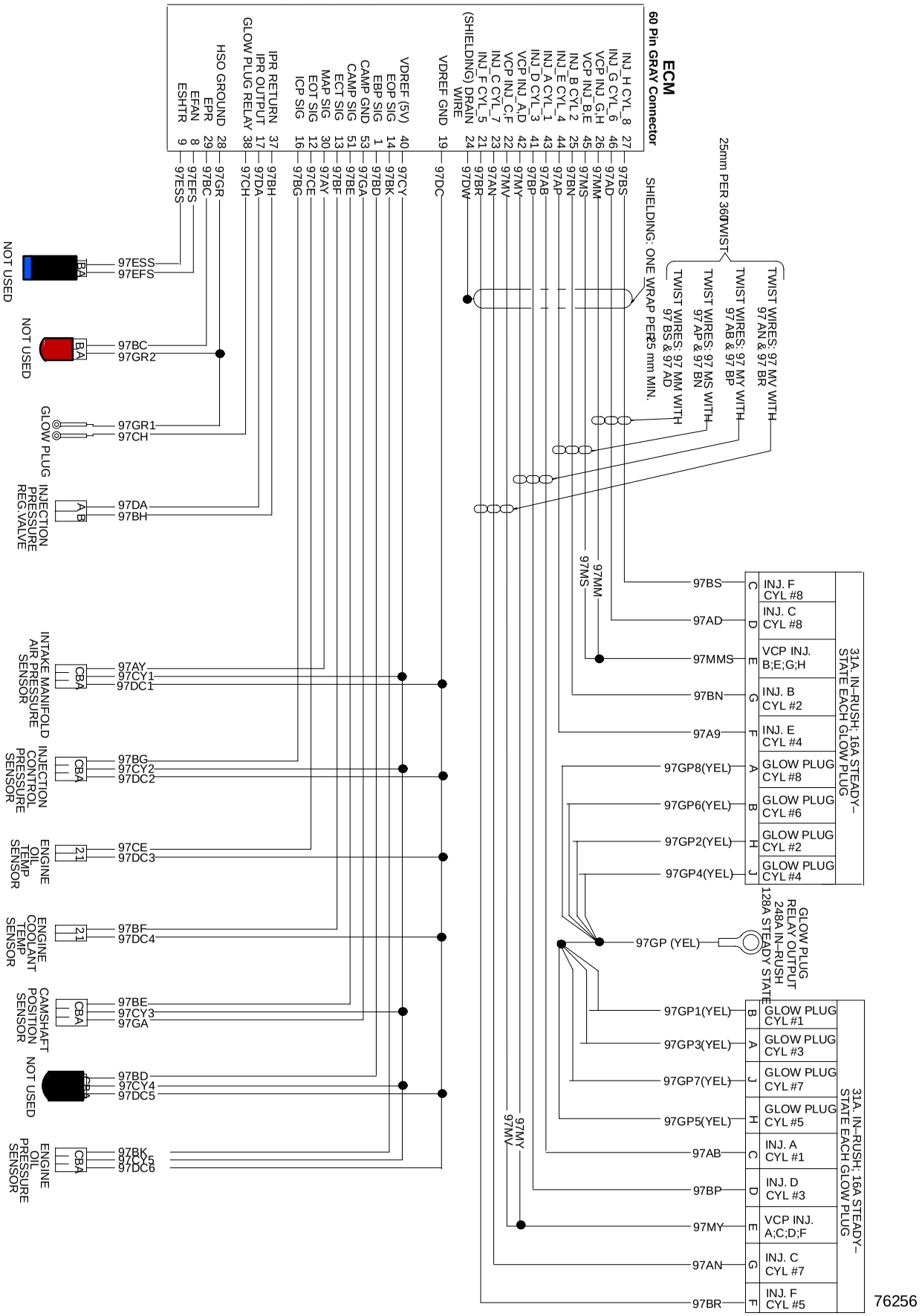
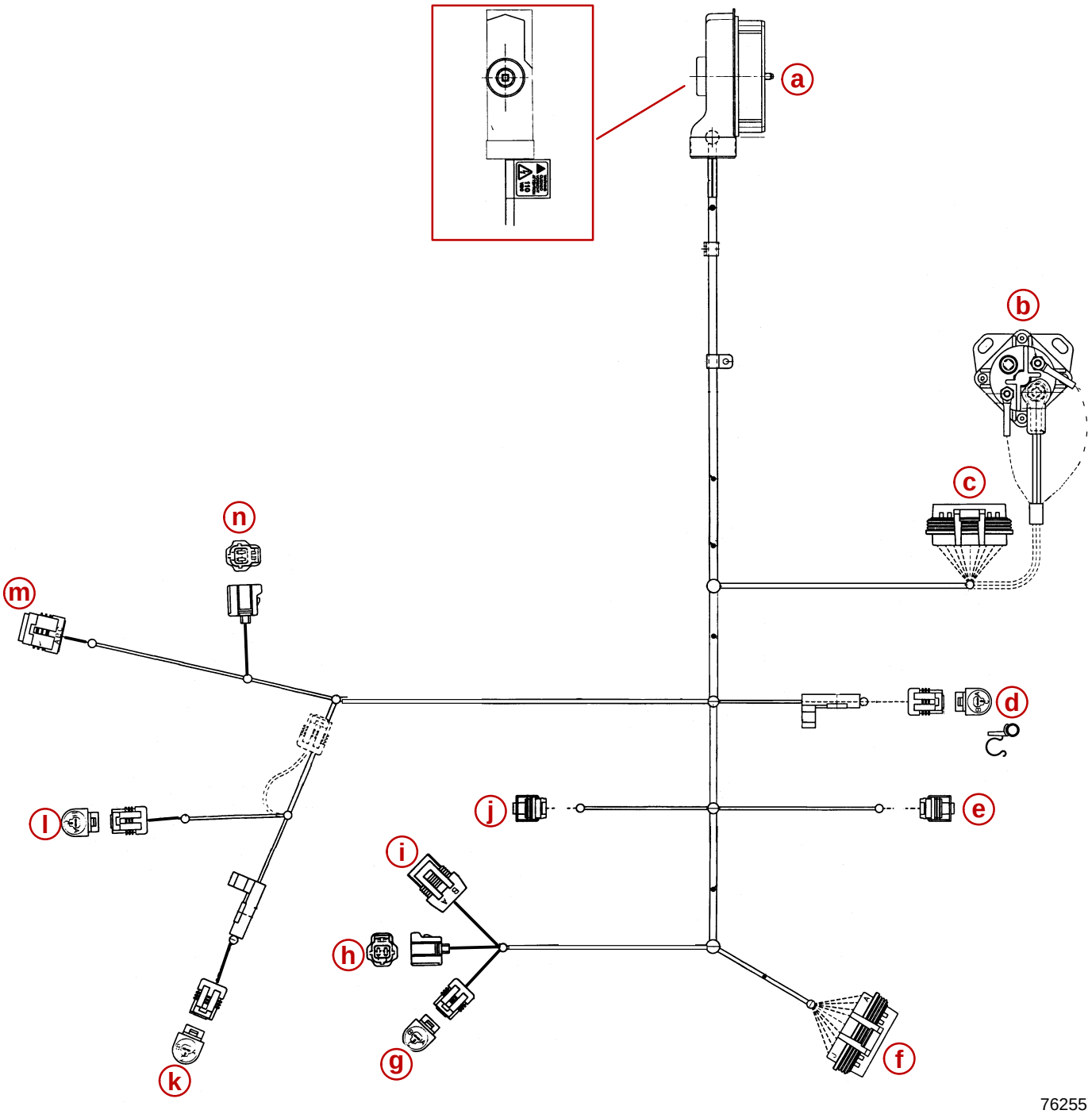
Engine Harness Schematic



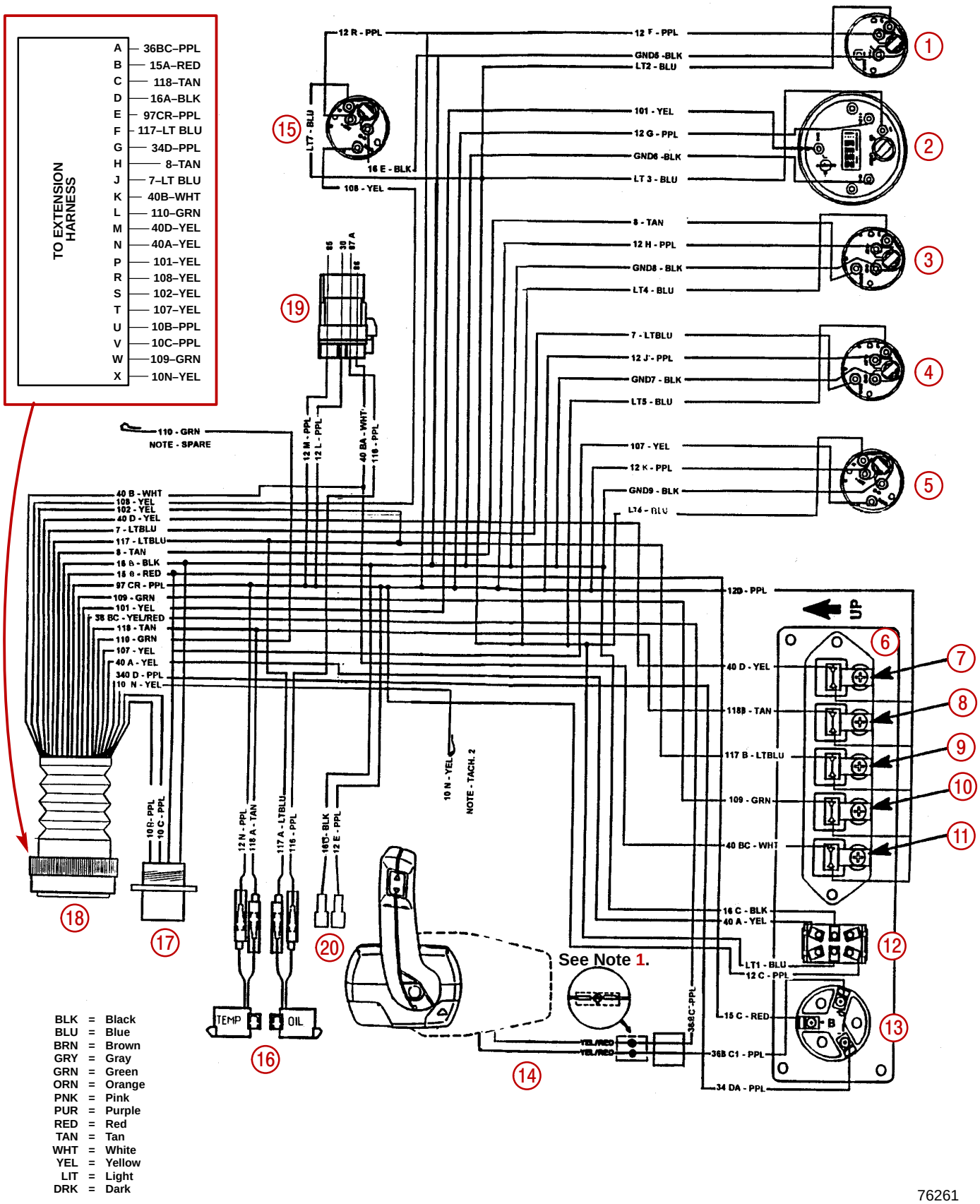
Engine Harness Assembly



a - ECM (GRAY) 60-Pin Connector
b - Glow Plug Relay
c - Starboard UVC Gasket Connector
d - MAP Sensor Connector
e - IPR Valve Connector
f - Port UVC Gasket Connector
g - EOT Sensor Connector
h - ICP Sensor Connector
i - Connector Not Used (Blue Plug)
j - Connector Not Used (Red Plug
k - EOP Sensor Connector
l - Connector Not Used (Taped Back - Black Plug)
m - CMP Sensor Connector
n - ECT Sensor Connector

Instrument Panel Wiring Diagrams

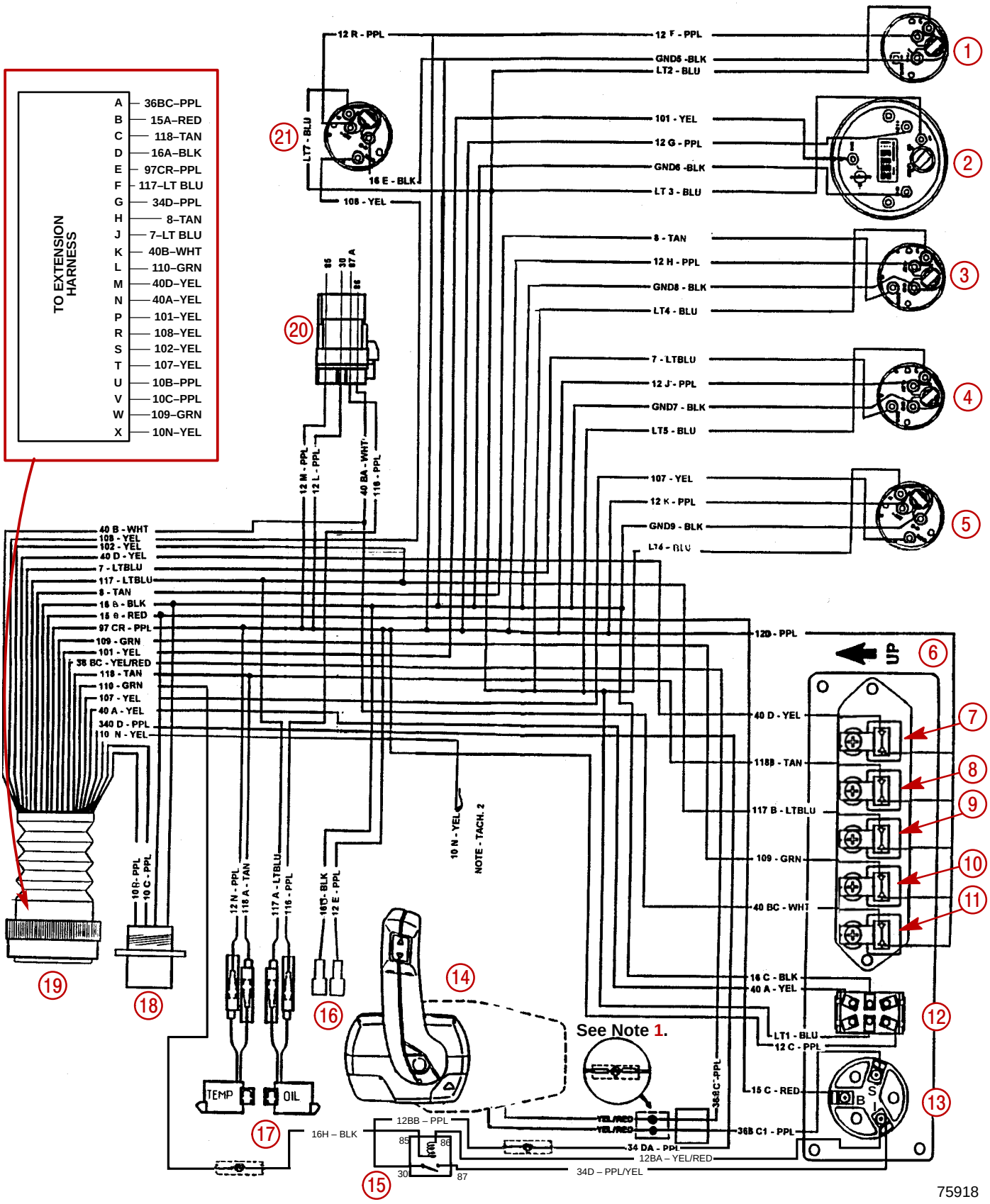
Primary Station Instrumentation (Single Station)



1 - Voltmeter Gauge
2 - Tachometer Gauge
3 - Water Temperature Gauge
4 - Oil Pressure Gauge
5 - Trim Gauge
6 - Engine System Monitor Panel
7 - Check Engine Light
8 - Engine Coolant High Temperature / Low Gear Lube Monitor Light
9 - Oil Pressure Warning Light
10 - Charge Indicator Light
11 - Preheat Indicator Light
12 - Panel Lights/Audio Warning Test Switch
13 - Key Switch
14 - Neutral Start Safety Circuit/Remote Control
15 - Fuel Gauge (Optional)
16 - Audio Warning Horns
17 - Diagnostic Tool Connection
18 - Instrument Harness Connector
19 - Wait-To-Start Relay
20 - Hour Meter Gauge (Optional)

Note 1: Connect these wires together with a screw and nut. Coat with Liquid Neoprene and slide rubber sleeve over connection.

Primary Station Instrumentation (With Relay for Second Station Installed)



1 - Voltmeter Gauge
2 - Tachometer Gauge
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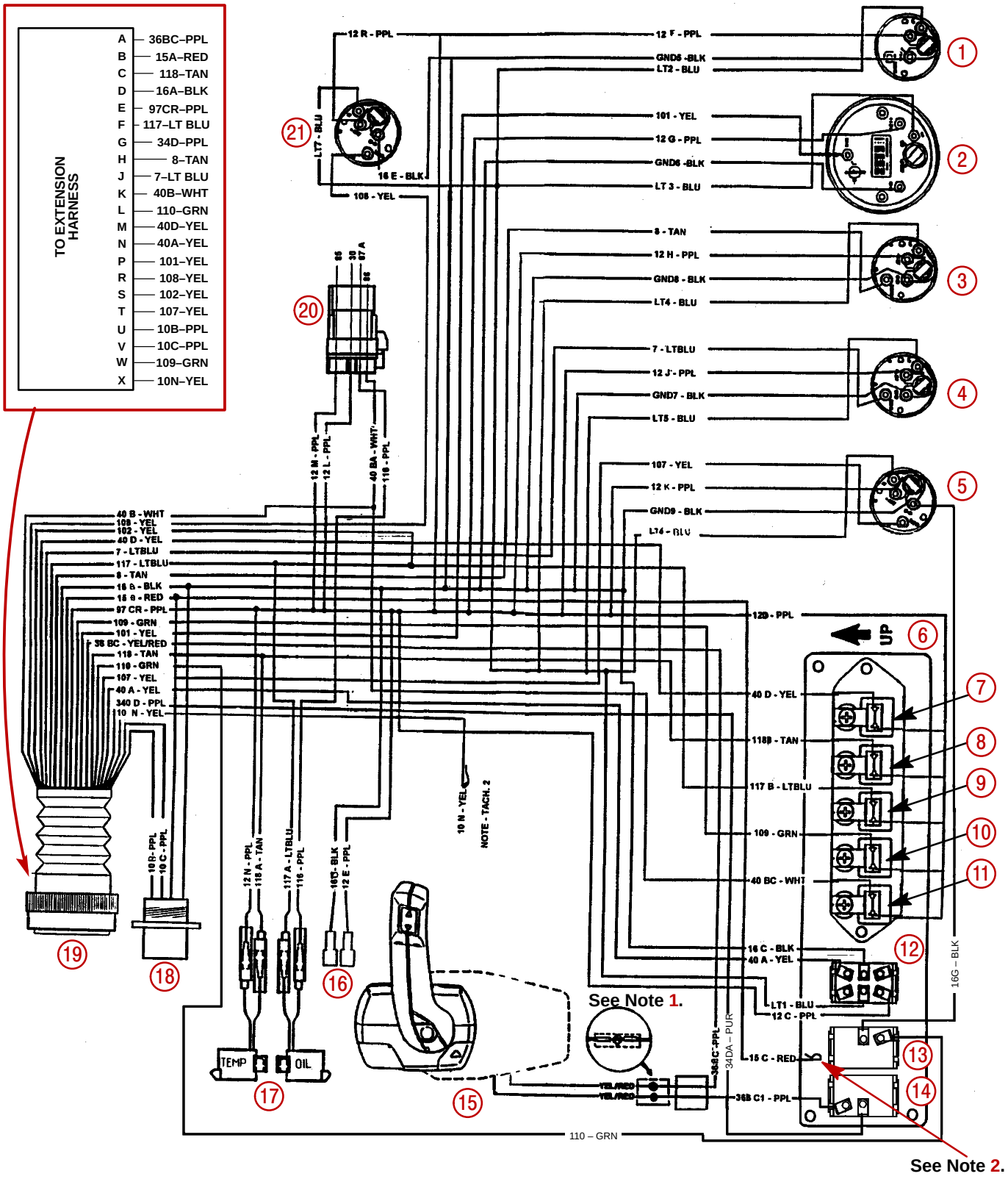
7 - Check Engine Light
8 - Engine Coolant High Temperature/ Low Gear Lube Monitor Light
9 - Oil Pressure Warning Light
10 - Charge Indicator Light
11 - Preheat Indicator Light
12 - Panel Lights/Audio Warning Test Switch
13 - Key Switch
14 - Neutral Start Safety Circuit/Remote Control
15 - Second Station Relay (From Kit)
16 - Hour Meter Gauge (Optional)
17 - Audio Warning Horns
18 - Diagnostic Tool Connection
19 - Instrument Harness Connector
20 - Wait-To-Start Relay
21 - Fuel Gauge (Optional)

Note 1: Connect these wires together with a screw and nut. Coat with Liquid Neoprene and slide rubber sleeve over connection.

Second Station Instrumentation



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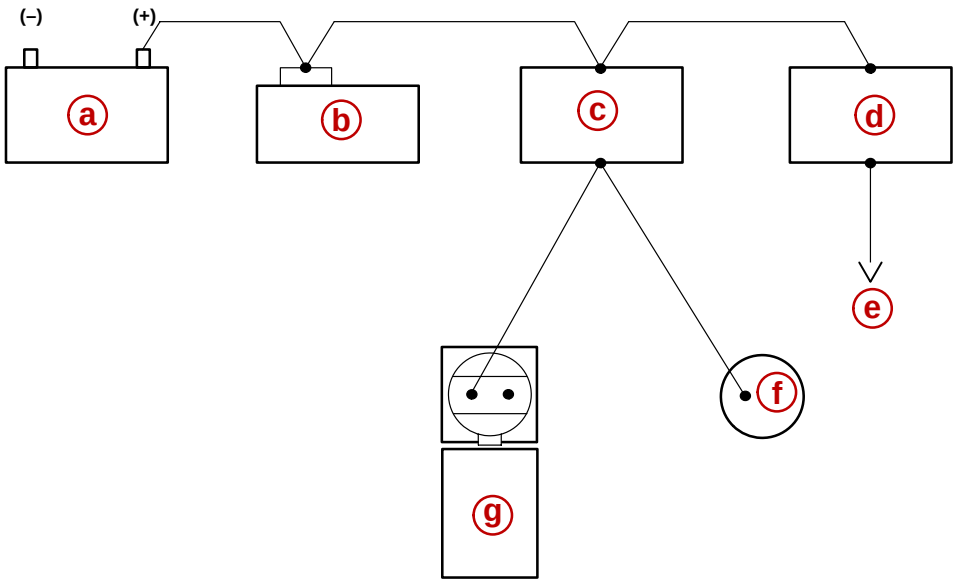
75919

1 - Voltmeter Gauge
2 - Tachometer Gauge
3 - Water Temperature Gauge
4 - Oil Pressure Gauge
5 - Trim Gauge
6 - Engine System Monitor Panel
7 - Check Engine Light
8 - Engine Coolant High Temperature/
Low Gear Lube Monitor Light
9 - Oil Pressure Warning Light
10 - Charge Indicator Light
11 - Preheat Indicator Light
12 - Panel Lights/Audio Warning Test Switch
13 - Stop Switch
14 - Start Switch
15 - Neutral Start Safety Circuit/Remote Control
16 - Hour Meter Gauge (Optional)
17 - Audio Warning Horns
18 - Diagnostic Tool Connection
19 - Instrument Harness Connector
20 - Wait-To-Start Relay
21 - Fuel Gauge (Optional)

Note 1: Connect these wires together with a screw and nut. Coat with Liquid Neoprene and slide rubber sleeve over connection.

Note 2: Wire not used. Tape wire end with at least two layers of electrical tape and tape back.

Circuit Breakers and Power Circuits



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a - Battery
b - Starter
c - 150 Amp Circuit Breaker
d - 30 Amp Circuit Breaker
e - To VBAT (+)
f - Alternator
g - GlowPlug Relay

FUEL SYSTEM

Section 5A - Engine Control System Overview

Table of Contents

Fuel Supply System 5A-3
Fuel System Description 5A-3
Fuel Supply Pump 5A-4
Fuel System Operation 5A-4
Injection Control Pressure System 5A-6
Pressure System Operation 5A-6
Injection Pressure Control 5A-7
IPR Valve Operation 5A-8
Injector Operation 5A-10
Description 5A-10
Electronic Control Module (ECM) - Operation and Function 5A-11
ECM Primary Functions 5A-11
1. Reference Voltage (V Ref) 5A-12
2. Signal Conditioner 5A-13
3. Microprocessor 5A-14
4. Actuator Control 5A-16
Sensor Operation 5A-21
Input Signals 5A-21
Reference Voltage Sensors 5A-21
Thermistor 5A-22
Potentiometer 5A-23
Variable Capacitance Sensor 5A-24
Hall Effect Sensor 5A-25
Switch Sensors 5A-26
Standard Features 5A-27
Electronic Governor Control 5A-27
Glow Plug Assisted Start 5A-27
ATA Data Link 5A-27
Service Diagnostics 5A-27
Engine Over-Temperature Protection . 5A-27
Event Logging System 5A-27
Electronic Throttle Position 5A-28
Diagnostic Software Self Test Operation . 5A-30
Test Chart 5A-30
Continuous Monitor 5A-32
Operator “On Demand” Tests (Engine Off) 5A-32
Injector Buzz Test 5A-34
Output State Test 5A-35
Operator “On Demand” Tests (Engine Running) 5A-36
Standard Test 5A-36
Injector Test “Cylinder Contribution” 5A-36
Wiggle Test 5A-37
Sensor/Sender Locations 5A-38
Relays 5A-38
MerCathode Controller And Fuse 5A-38
Circuit Breakers 5A-38
Cam Position Sensor (CMP) 5A-39
Accelerator Position Switch / Idle Validation Switch (APS/IVS) 5A-39
Manifold Absolute Pressure (MAP) Sensor 5A-39
Barometric Pressure (BARO) Sensor . 5A-40
Intake Air Temperature (IAT) Sensor . 5A-40
Engine Coolant Temperature (ECT) Sensor 5A-40
Engine Oil Temperature (EOT) Sensor 5A-41
Coolant Temperature Sender (To Gauge) 5A-41
Oil Temperature Sender (To Gauge) . . 5A-41
Coolant Temperature Switch (To Alarm) 5A-42
Oil Temperature Switch (To Alarm) . . . 5A-42
Tachometer Pickup 5A-42
Injection Control Pressure Sensor (ICP) 5A-43
Glow Plug Solenoid 5A-43
Electronic Control Module (ECM) 5A-43

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Fuel Supply System

Fuel System Description

The fuel system consists of three major sub-systems:

- Fuel Supply System
- Injection Control Pressure System
- Fuel Injector

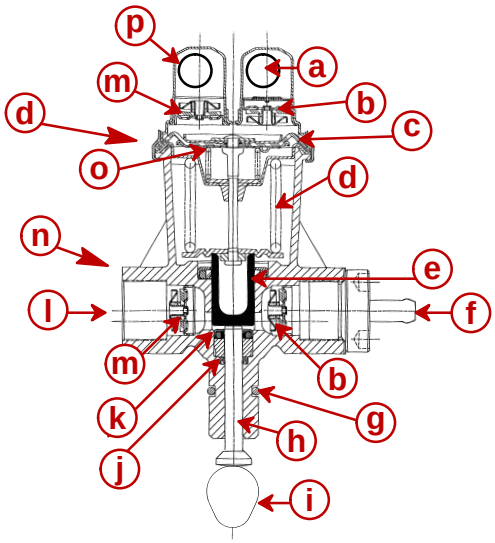
These subsystems work together to inject pressurized fuel into the combustion chambers. The function of the fuel supply system is to deliver fuel to the injectors. The injection control pressure system supplies the injectors with high pressure lube oil. The fuel injectors use the pressure from the lube oil to pressurize the fuel and inject the fuel into the combustion chambers.

The function of the fuel supply system is to deliver fuel from the fuel tank(s) to the injectors. The components involved in this task are:

- Fuel Lines
- Fuel Strainer
- Transfer Fuel Pump
- Fuel Filter / Water Separator
- Fuel Pressure Regulator Valve

Fuel Supply Pump

The fuel transfer pump on the engine is a camshaft driven two stage diaphragm / piston pump mounted in the engine “V.”



a - Fuel Inlet
b - Inlet Check Valve
c - Diaphragm
d - Spring
e - Piston
f - Inlet
g - O-Ring
h - Tappet
i - Camshaft Lobe
j - Oil Seal
k - Fuel Seal
l - High Pressure Outlet
m - Outlet Check Valve
n - Piston Stage
o - Diaphragm Stage
p - Low Pressure Fuel Out

Fuel System Operation

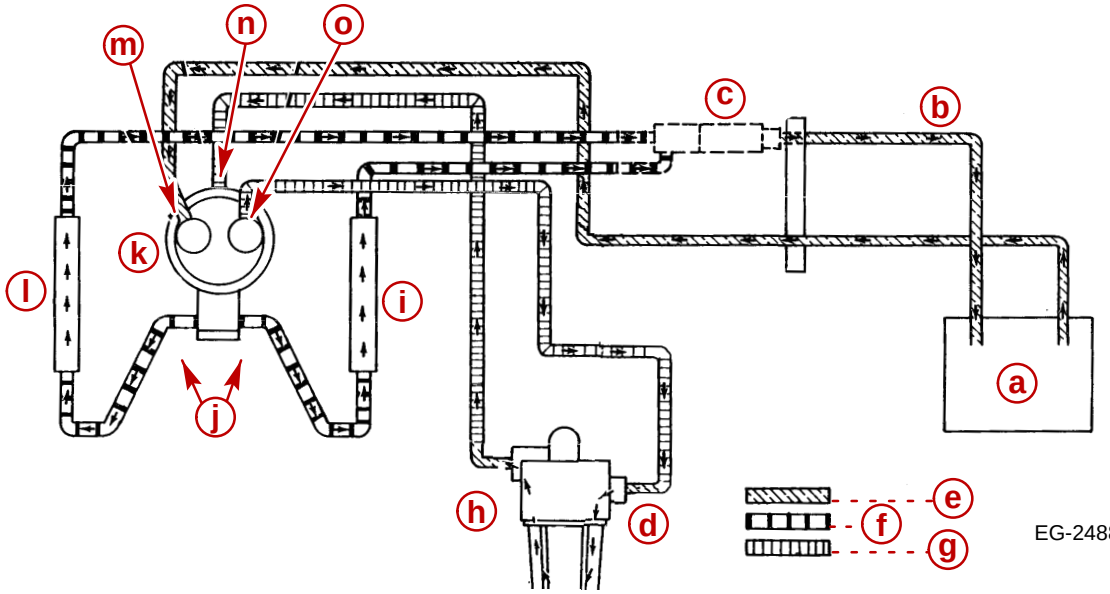
The diaphragm stage of the tandem lift pump draws fuel from the tank. Pressurized fuel 4 to 6 psi (28 to 41 kPa) from the diaphragm stage is supplied to the fuel filter.

Fuel in the filter housing passes through the filter element to a standpipe in the center of the filter assembly. Clean fuel is then routed to the inlet of the piston stage of the tandem pump.

The piston stage of the tandem pump raises fuel pressure from 4 psi to 40 psi (28 to 276 kPa) to insure proper filling of the injectors. Fuel from this stage is divided through steel lines to the back of each cylinder head. These lines supply fuel to a gallery drilled in each cylinder head. The gallery intersects each injector bore in the cylinder head.

Return fuel from the two fuel galleries is routed through hoses, of a special rubber compound, from the front of each head to the pressure regulator. These hoses provide flexibility in the fuel system by absorbing and smoothing pressure pulses from the piston stage of the pump.

The fuel regulator valve contains a spring loaded valve to control pressure in the fuel galleries to 40 psi (276 kPa). Return fuel flows through the regulator and is routed to the fuel tank(s).



FUEL FLOW DIAGRAM

- **a** - Fuel Tank
- **b** - Return Fuel
- **c** - Fuel Regulator Valve
- **d** - Unfiltered Fuel In
- **e** - Negative Pressure
- **f** - High Pressure
- **g** - Low Pressure
- **h** - Filtered Fuel Out
- **i** - Starboard Fuel Rail
- **j** - Second Stage High Pressure Outlets 50-60 PSI
- **k** - Tandem Fuel Supply Pump
- **l** - Port Fuel Rail
- **m** - Low Pressure Inlet
- **n** - High Pressure Inlet
- **o** - Low Pressure Outlet 3-10 PSI

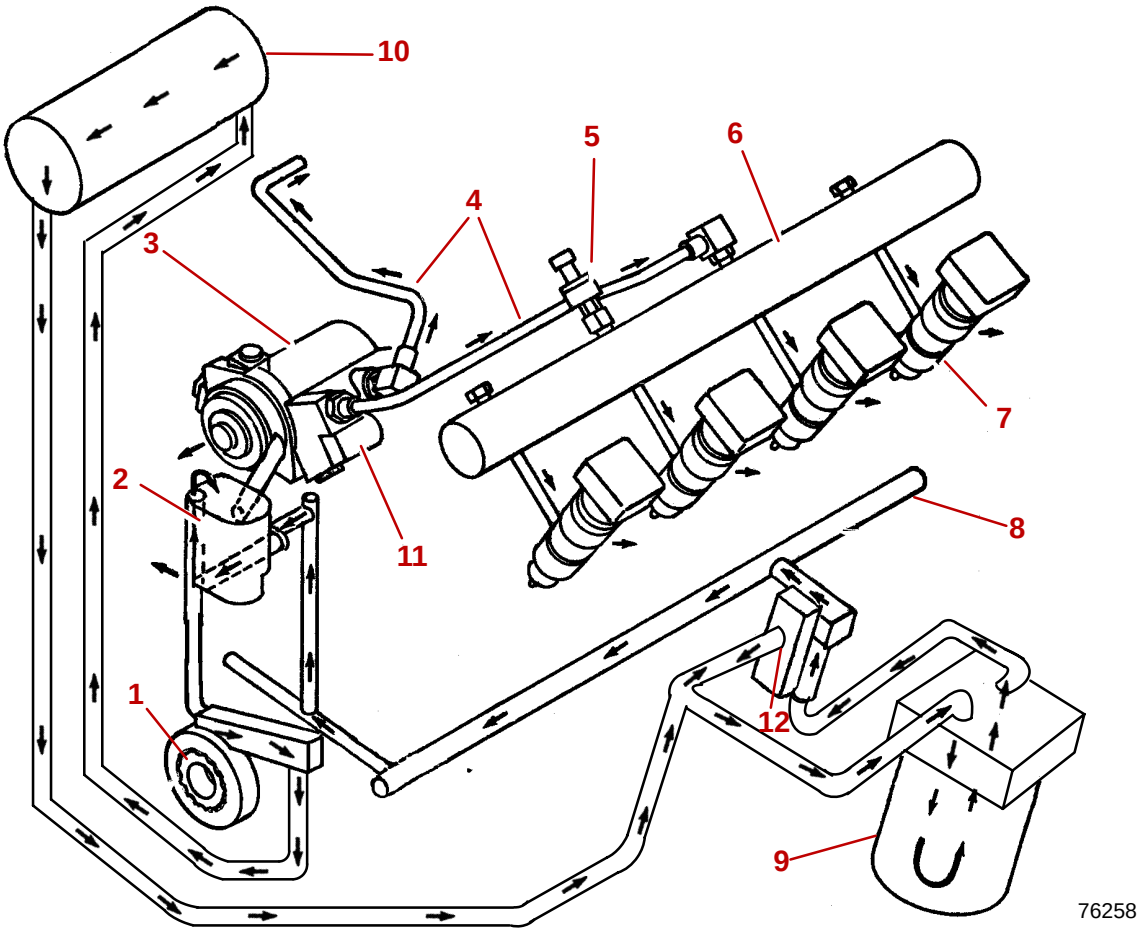
Injection Control Pressure System

Pressure System Operation

The system utilizes a hydraulically actuated injector to pressurize fuel inside the injector. The hydraulic fluid used to actuate the injector is engine oil.

Oil is drawn from the oil pan through the pickup tube by the engine oil pump. The engine oil pump is a gerotor type pump driven by the crankshaft. Oil is fed through passages in the front cover to an oil reservoir mounted on top of the front cover.

The reservoir makes available a constant supply of oil to a high pressure hydraulic pump mounted in the engine “V.” The high pressure pump is a gear driven seven plunger swash plate pump. High pressure oil is delivered by the high pressure pump to oil galleries machined into the cylinder heads, drilled intersecting passages supply high pressure oil to the injector.

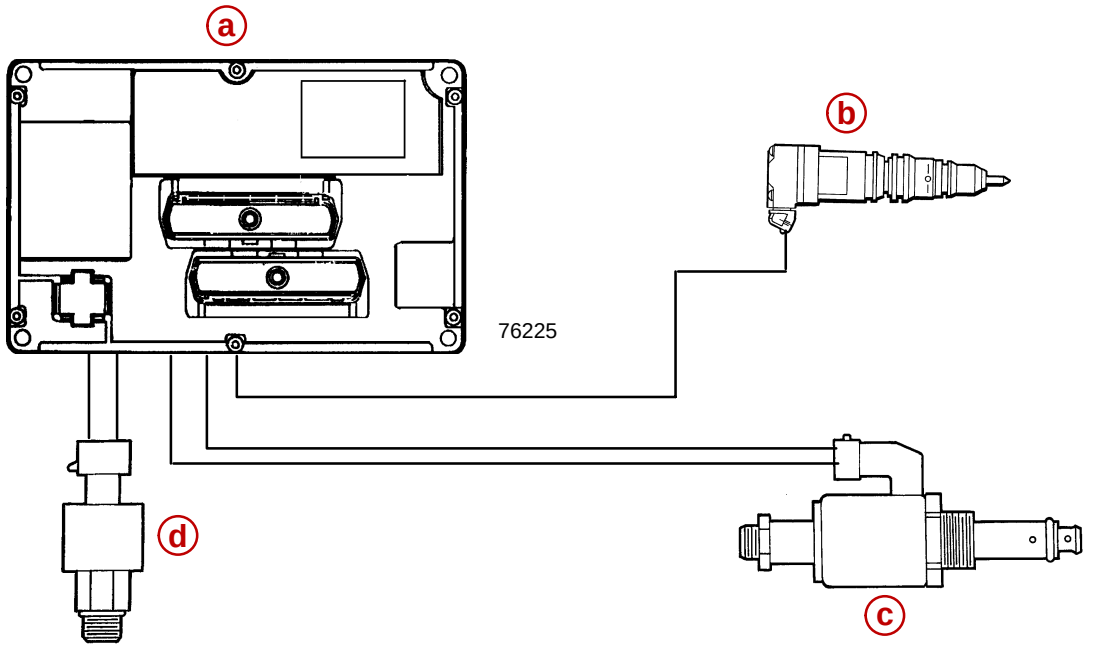


1 - Oil Pump
2 - Reservoir (Located On Top of Front Cover)
3 - High Pressure Pump
4 - High Pressure Hoses
5 - Injection Control Pressure Sensor
6 - Cylinder Head High Pressure Rail
7 - Injector (8)
8 - Gallery (Crankcase)
9 - Oil Filter
10 - Oil Cooler
11 - Injection Control Pressure Regulator
12 - Oil Filter By-Pass Valve/Oil Pressure Regulator

Injection Pressure Control

The injection control pressure system is a closed loop operating system. The system consists of the Electronic Control Module (ECM), Injection Control Pressure Sensor (ICP) and the Injection Pressure Regulator (IPR) valve.

The ECM is programmed with an injection pressure control strategy which determines the correct injection control pressure at each engine operating condition. The ECM receives a 0-5 volt DC analog feedback signal from the ICP sensor located in the high pressure oil supply gallery on the left cylinder head that indicates Injection Control Pressure information. The ECM processes this signal and controls Injection Control Pressure by controlling the ground signal to the IPR regulating valve.



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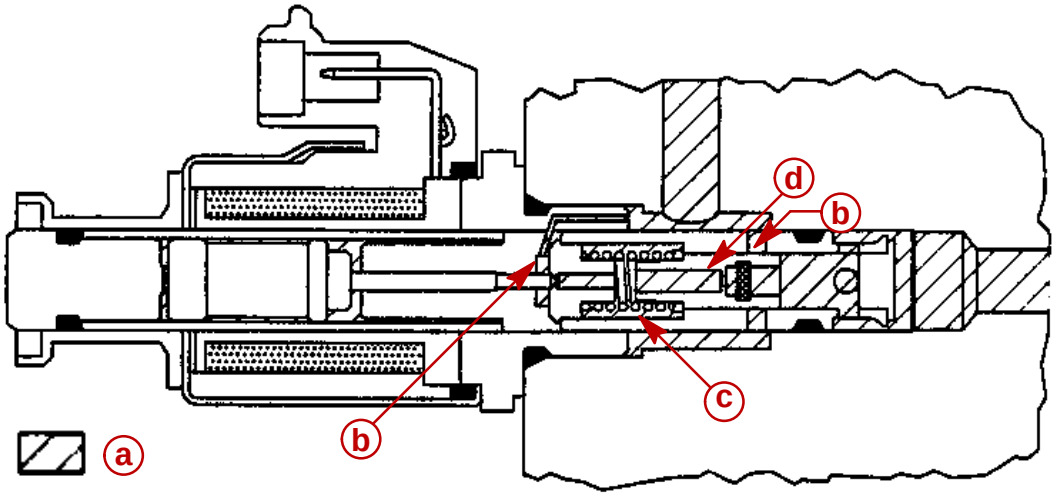
Injection Control System

- **a** - ECM
- **b** - Injector
- **c** - IPR Valve
- **d** - ICP Sensor

IPR Valve Operation

The Injection Pressure Regulator valve is a pulse width modulated valve operating at 400 Hz. The pulse width is modulated from a duty cycle of 0 to 50% to control ICP pressure from 500 to 3000 psi (3.4 to 20 mPa). The regulator valve is mounted in the high pressure pump and achieves injection control pressure regulation by dumping excess oil through a spool valve (shuttle) into the front cover and back to sump.

The following diagram illustrates the IPR valve in the Engine Off state. The spool valve is held closed (to the right) by the return spring and the drain ports are closed.



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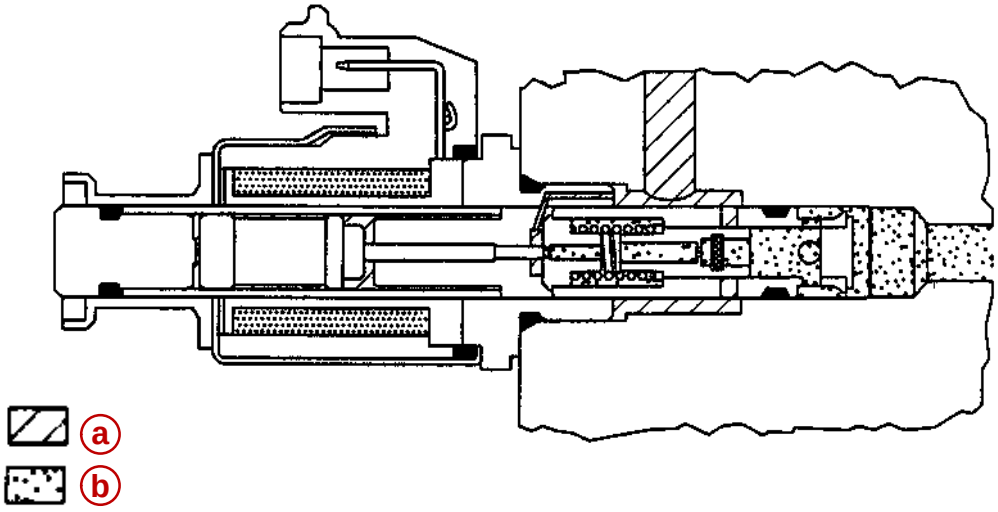
Engine Off

a - Drain
b - Drain Port
c - Return Spring
d - Spool Valve

The following diagram illustrates the IPR valve in the Engine Cranking state. The ECM signals the IPR valve to close directing all the oil to flow into the oil supply galleries building oil pressure as quickly as possible to start the engine.

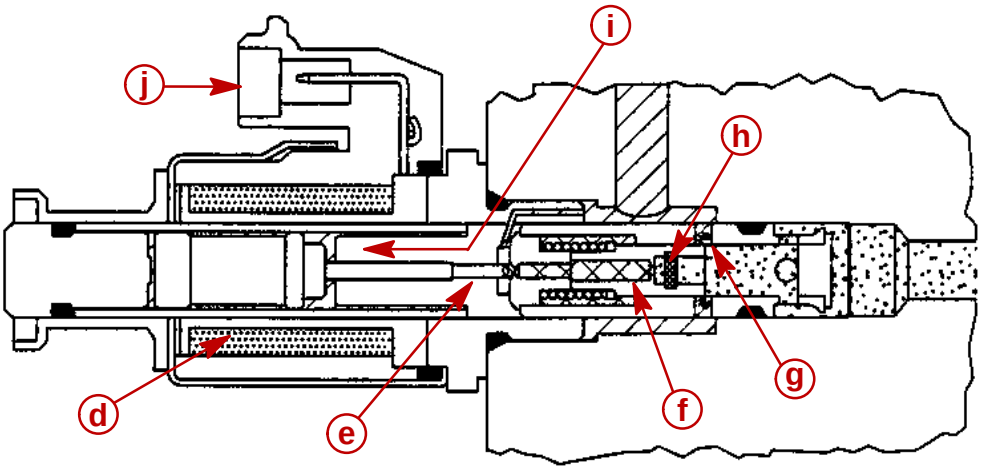


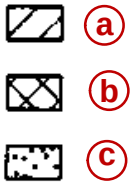
EG-1093

Engine Cranking

a - Drain
b - Pump Outlet Pressure

The following diagram illustrates the IPR valve in the Engine Running state. The ECM pressure regulating signal determines the magnetic field strength of the IPR valve solenoid. The magnetic field pulls the poppet to the left as shown. This action allows the pump outlet pressure that is on the spool valve to move the spool valve to the new position of the poppet. Poppet movement allows a small amount of oil to enter the spool chamber through the spool valve control orifice and filter.





EG-1094

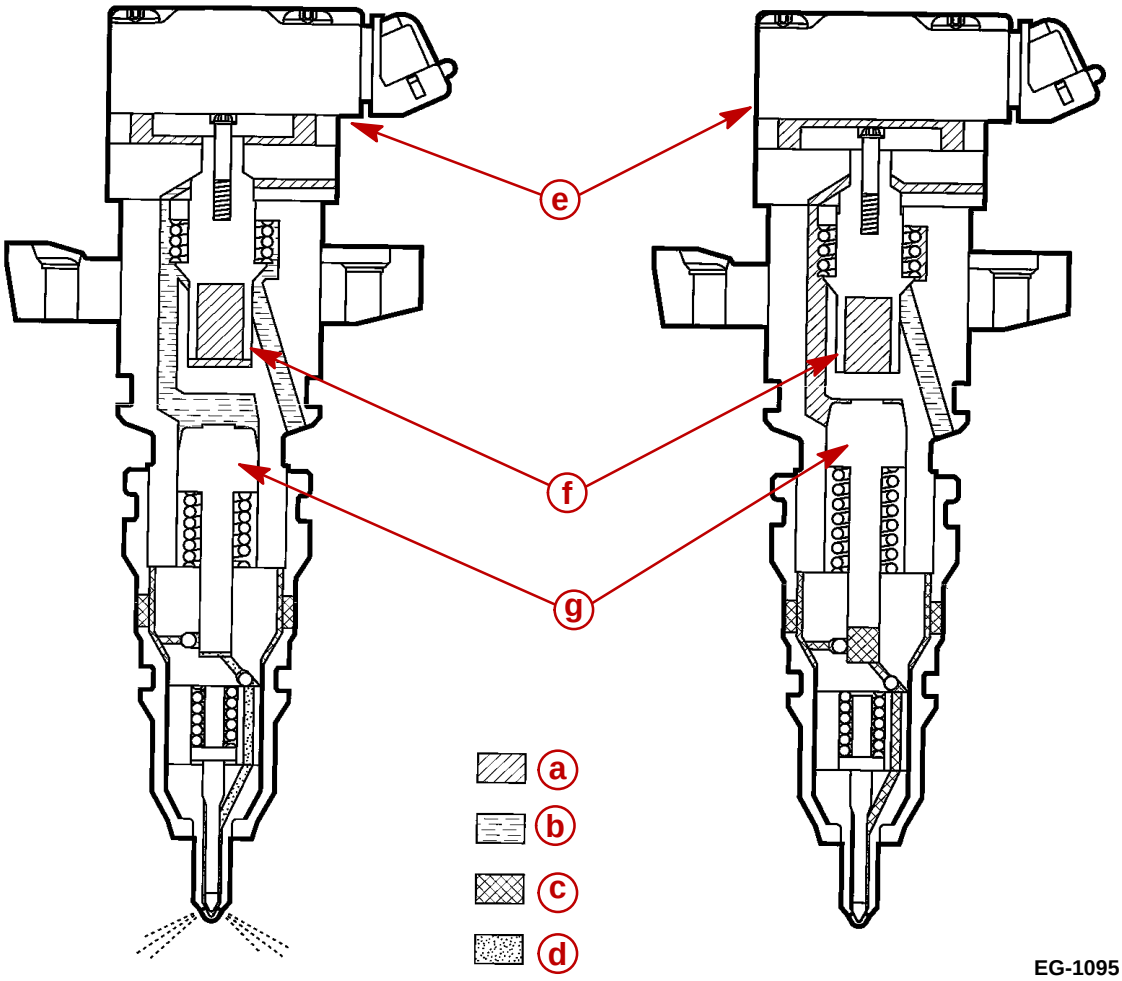
Engine Running

- **a** - Drain
- **b** - Spool Chamber Pressure
- **c** - Pump Outlet Pressure
- **d** - Solenoid Winding
- **e** - Poppet
- **f** - Spool Valve
- **g** - Pump Outlet Drain Port
- **h** - Control Orifice and Filter
- **i** - Poppet Movement
- **j** - ECM Pressure Regulating Signal

Injector Operation

Description

When an injector is energized, the poppet valve is opened by an electronic solenoid mounted on the injector. Oil pressure is allowed to flow into the injector and act on the amplifier piston. When injection is ended the pressure on top of the amplifier piston is vented by the poppet valve through the top portion of the injector and directed by the oil troughs mounted on the injector to a push tube hole for return to the oil sump.



Energized Injector **De-Energized Injector**

a - Atmospheric Pressure
b - Rail Pressure
c - Fuel Supply Pressure
d - Injection Pressure
e - Electronic Solenoid
f - Poppet Valve
g - Amplifier Piston

Electronic Control Module (ECM) - Operation and Function

The Electronic Control Module (ECM) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards.

To understand how the ECM functions and how it can monitor input signals and exert control over the actuators it is necessary to view the four primary functions of the ECM.

ECM Primary Functions

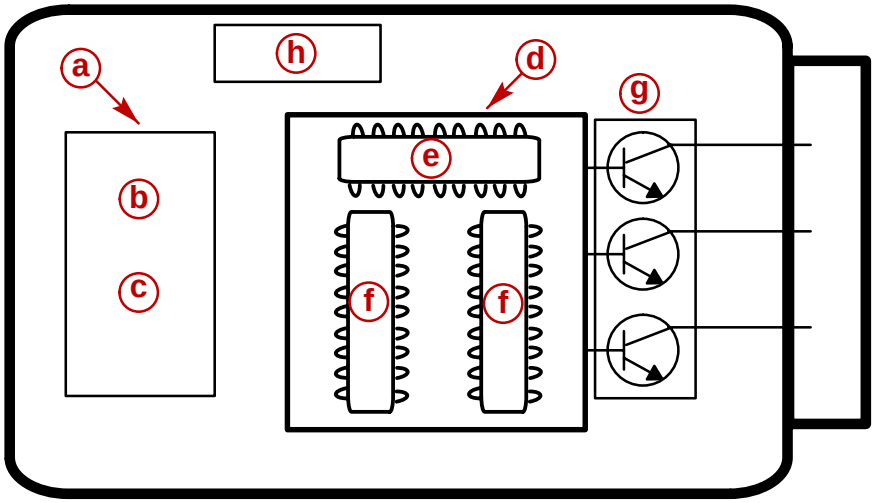
1. **Reference Voltage (V Ref)**
2. **Signal Conditioner**

- Amplifiers (AMP)
- Analog to Digital Converter (A/D Converter)

3. **Microprocessor**

- Processor
- Memory (RAM and ROM)

4. **Actuator Control**



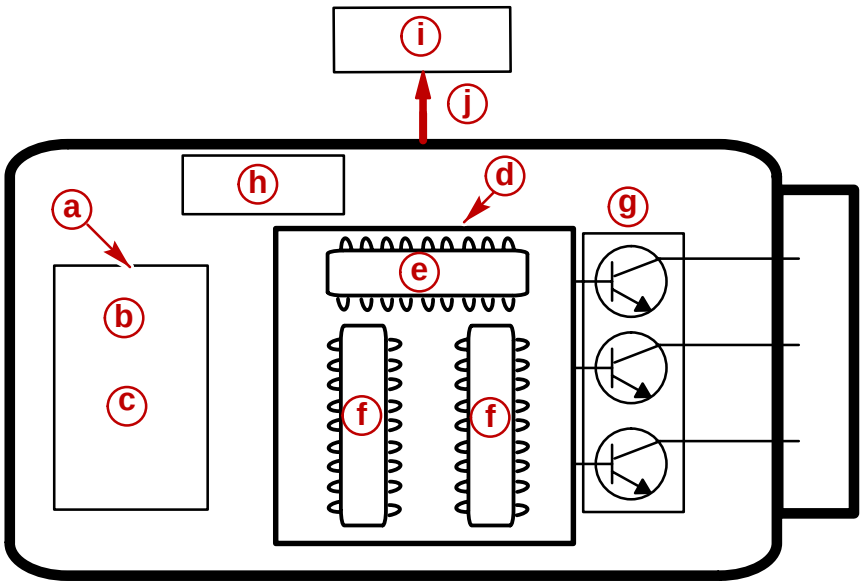
Electronic Control Module (ECM)

a - Input Conditioner
b - Amplifiers
c - Analog to Digital Converter
d - Microcomputer
e - Microprocessor
f - Memory
g - Output Drivers
h - Reference Voltage Regulator

1. REFERENCE VOLTAGE (V Ref)

The ECM supplies a 5 volt reference signal to many of the input sensors in the control system. On most circuits the ECM compares the regulated 5 volts sent to the sensors by the modified returned signal and is able to determine temperature, pressure, speed, position and many other variables that are important to engine and vessel functions. This 5 volt signal is current limited by a current limiting resistor in the event of an external short to ground.

For some sensors, like CMP (Camshaft Position), the 5 volts signal is a power source that powers up the circuitry in the sensor.

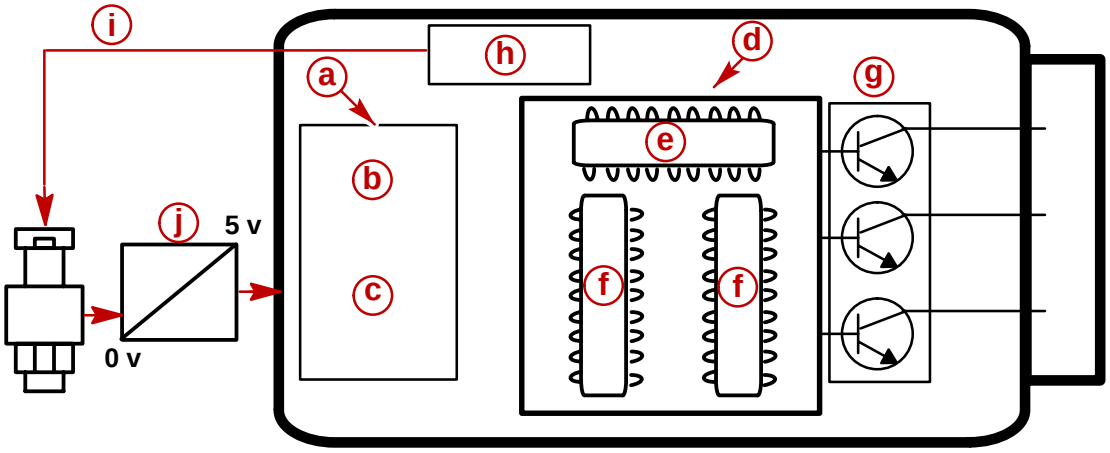


ECM 5 Volt Reference

- **a** - Input Conditioner
- **b** - Amplifiers
- **c** - Analog to Digital Converter
- **d** - Microcomputer
- **e** - Microprocessor
- **f** - Memory
- **g** - Output Drivers
- **h** - Reference Voltage Regulator
- **i** - Input Sensors
- **j** - 5 Volt V Ref

2. SIGNAL CONDITIONER

It conditions the input signals for the internal microprocessor. This enables the microprocessor to interpret the signals. Signal conditioning usually consists of converting analog signals to digital signals, squaring up sine wave signals or amplifying low intensity signals to a level the ECM microprocessor can process.



ECM Signal Conditioning

- **a** - Input Conditioner
- **b** - Amplifiers
- **c** - Analog to Digital Converter
- **d** - Microcomputer
- **e** - Microprocessor
- **f** - Memory
- **g** - Output Drivers
- **h** - Reference Voltage Regulator
- **i** - 5 Volt V Ref
- **j** - Analog Signal

3. MICROPROCESSOR

Processor

The ECM contains an internal microprocessor. The processor stores operating instructions (control strategies) and tables of values (calibration parameters). It compares these stored instructions and values to sensed input values to determine the correct operating strategy for any given engine condition. Calculations in the ECM occur at two different levels or speeds referred to as the foreground and the background calculations. These calculations are performed on a continuous closed loop basis.

The foreground calculations occur at a much faster rate than the background calculations. These are normally the more critical functions to engine operation or they occur at a faster rate. Such as engine speed control. Background calculations are normally things that occur at a slower pace such as engine temperature.

Diagnostic strategies (instructions) are also programmed into the ECM. Some instructions cause inputs or outputs to be monitored on a continuous basis and will flag a code that will be set. Other strategies will inform the ECM to perform certain tests upon operator demand.

The ECM's microprocessor is equipped with two types of memory Random Access Memory (RAM) and Read Only Memory (ROM). They allow the processor to store the necessary instructions, calibration tables and input values to control the engine.

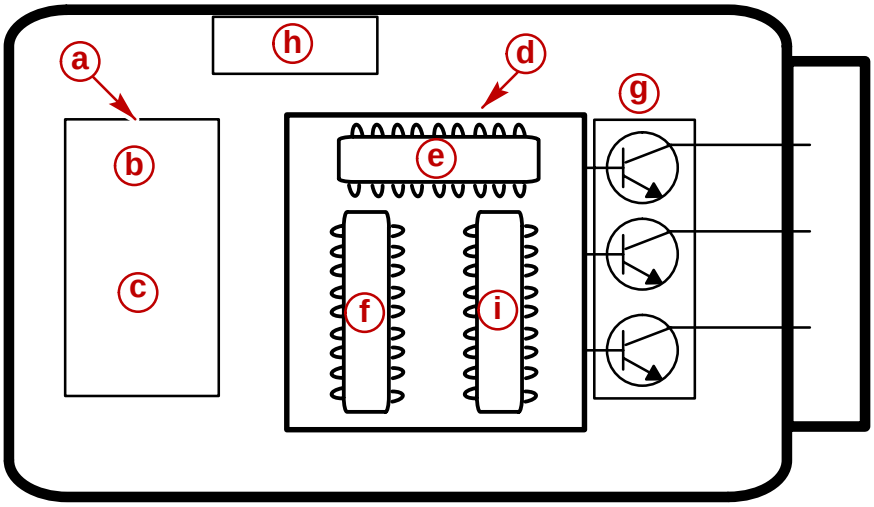
RAM

Random Access Memory is a temporary storage memory for current events such as current engine temperature or current speed, pedal position, etc. It is the memory to which information is temporarily stored so that it can be compared to the information in the ROM. Unlike the ROM memory, the RAM is lost every time the key is turned OFF or when power is interrupted to the ECM.

3. MICROPROCESSOR (CONTINUED)

ROM

Read Only Memory is the memory where calibration tables and operating strategies are stored. Information in the ROM is permanent. It can not be changed or lost by turning the engine OFF or disconnecting the batteries.



ECM Microprocessor Memory

- **a** - Input Conditioner
- **b** - Amplifiers
- **c** - Analog to Digital Converter
- **d** - Microcomputer
- **e** - Microprocessor
- **f** - ROM
- **g** - Output Drivers
- **h** - Reference Voltage Regulator
- **i** - RAM

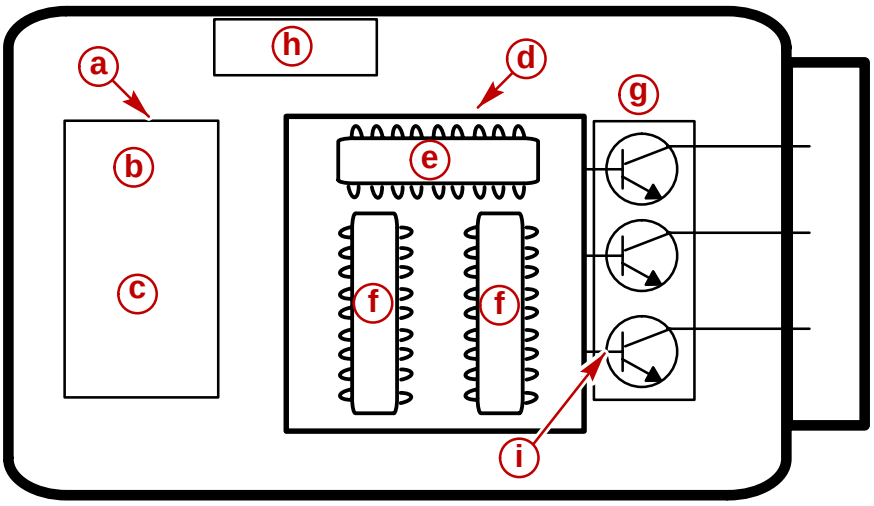
4. ACTUATOR CONTROL

ECM

The ECM controls the actuators by applying a low level signal to the base of the transistor output drivers. These drivers, when switched on, will complete the ground circuit of each actuator. The actuators are controlled in several ways:

- By duty cycle (% time on/off)
- By a controlled pulse width
- By being switched on or off.

The manner of control is determined by the type of actuator being controlled.



ECM Actuator Control

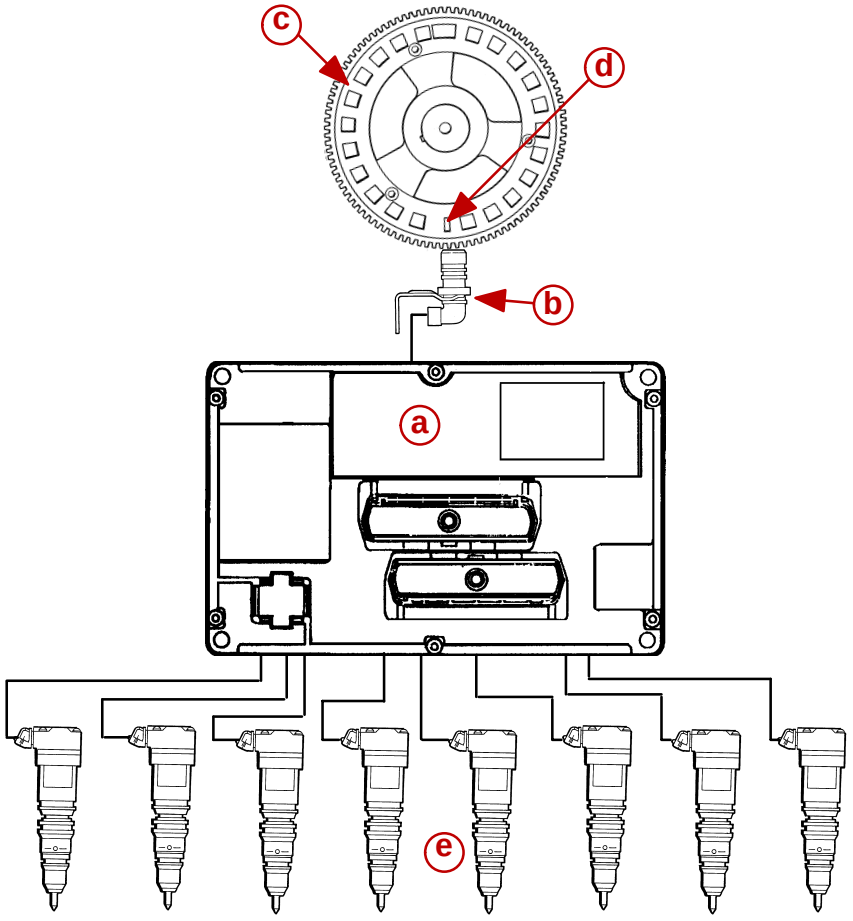
a - Input Conditioner
b - Amplifiers
c - Analog to Digital Converter
d - Microcomputer
e - Microprocessor
f - Memory
g - Output Drivers
h - Reference Voltage Regulator
i - ECM (Low Level) Actuator Control (Signal In)

4. ACTUATOR CONTROL (CONTINUED)

Electronic Distributor For The Injectors

The Electronic Control Module (ECM) monitors the engine speed and cylinder positions by constantly monitoring the camshaft position signal from the CMP sensor. The CMP sensor is a Hall effect sensor which looks for a narrow vane on the timing sensor disk. The timing sensor disk is precisely mounted and indexed on the camshaft gear in a relationship that identifies the position of number 1 piston.

When the ECM senses the narrow vane of the timing sensor disk through the CMP signal, it locates the position of the piston on cylinders number 1 and number 4. Based on those two cylinders it determines the position of the other pistons. This information is used to determine the correct injector firing sequence.



EG-7367

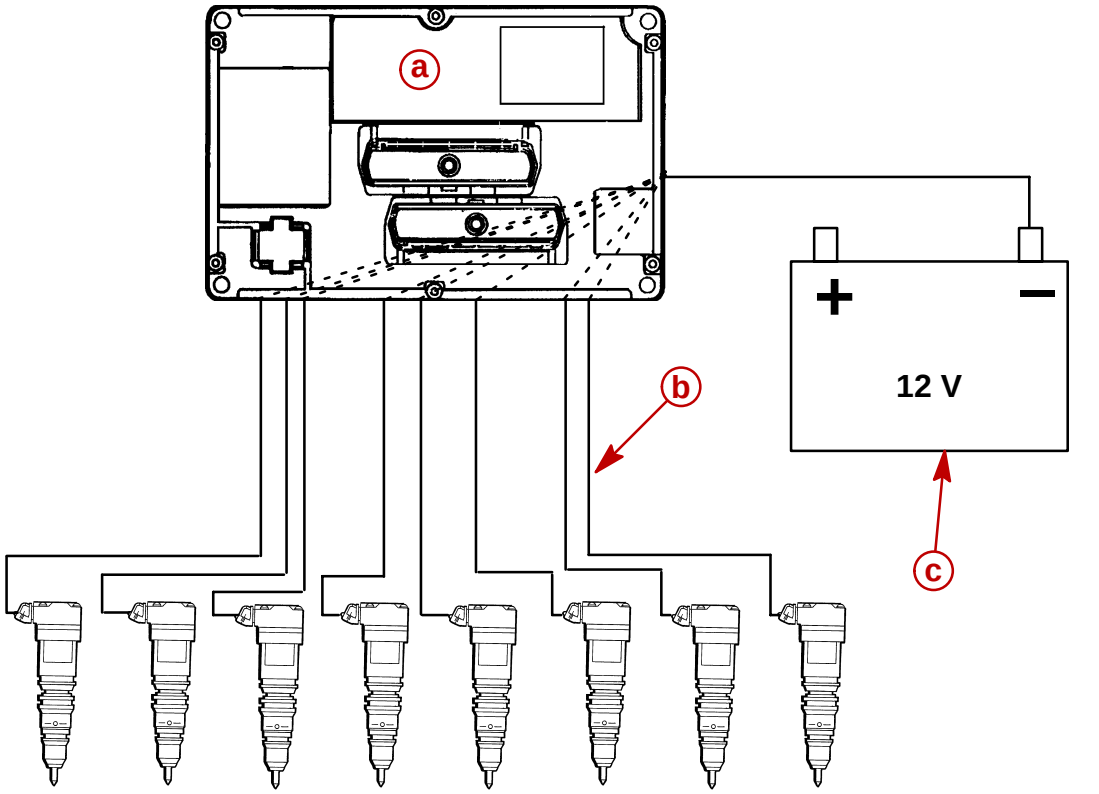
Electronic Distributor For Injectors

- **a** - ECM
- **b** - CMP Sensor
- **c** - Timing Sensor Disk
- **d** - Narrow Window
- **e** - Injectors

4. ACTUATOR CONTROL (CONTINUED)

Ground Source For The Injectors

The ECM provides a constant ground path to all the injectors.



76228

Injector Ground Supply

- **a** - ECM
- **b** - Supply Grounds (8)
- **c** - Battery (Voltage)

4. ACTUATOR CONTROL (CONTINUED)

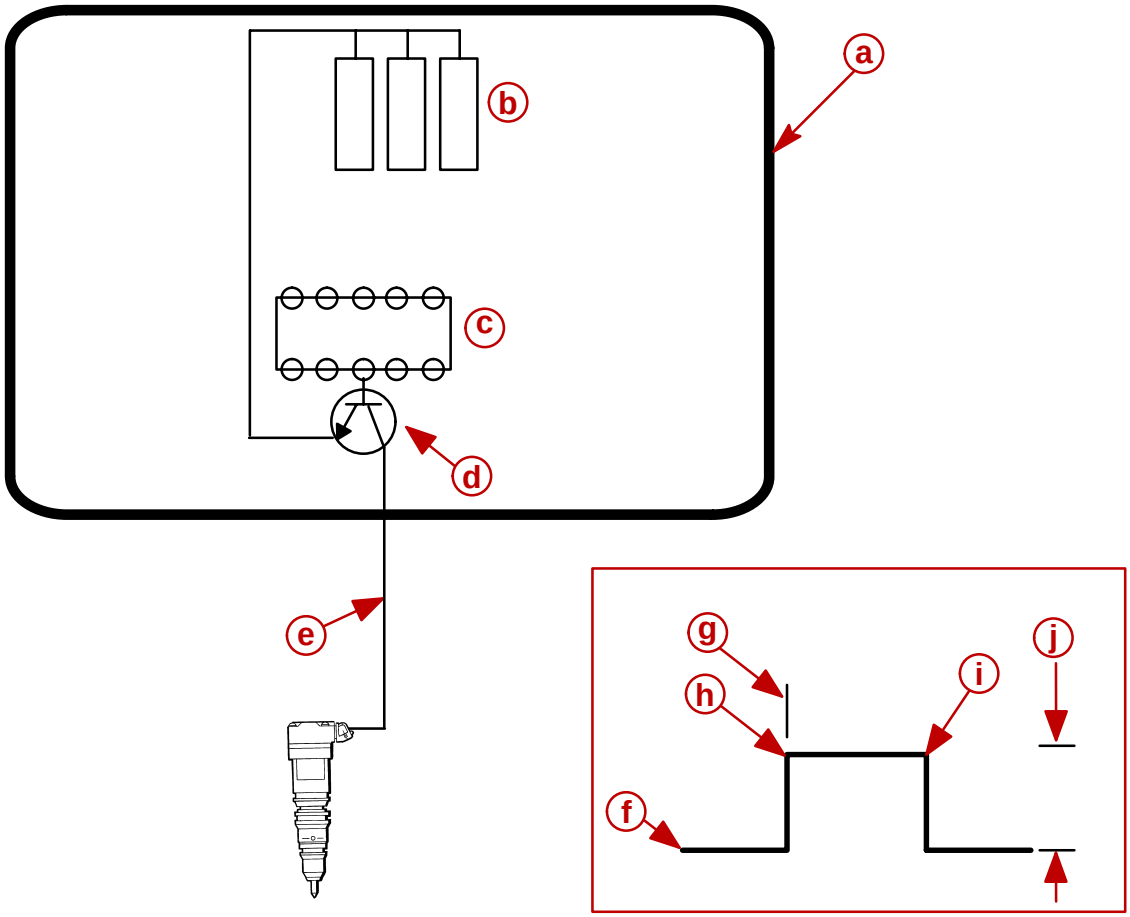
Power Source and Output Drivers For The Injectors

By using output driver transistors, the ECM supplies 115+ volts DC to each injector following the firing order. The ECM contains an individual output driver for each of the injectors.

The processor of the ECM determines the following:

- The correct firing sequence
- Timing of the injectors
- Duration of the injection

The 115 volt DC supply is created in the ECM by making and breaking a 12 volt source across an internal coil, based on the same principle as the automotive ignition coil.



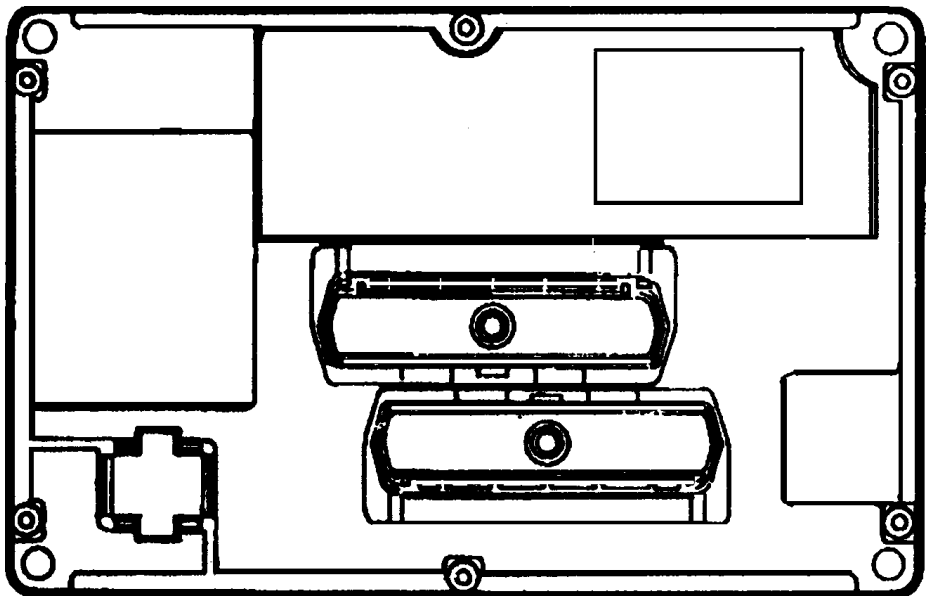
Driver Ground Circuit

a - ECM
b - Capacitors
c - Microprocessor
d - Driver
e - Injector Power Supply Voltage 115 Volt
f - Injection Signal from the ECM to the Injector
g - Injection Timing
h - Beginning of Injection
i - End Of Injection
j - 115 Volts

4. ACTUATOR CONTROL (CONTINUED)

Self Diagnostics

The ECM is capable of identifying if an injector is drawing too much or too little current and records a fault code that can be accessed by the technician. This code can be used to identify potential problems in either the wiring harness or injector. The ECM also performs self diagnostic checks that can set a code to indicate what has failed and needs to be replaced.



ECM

Sensor Operation

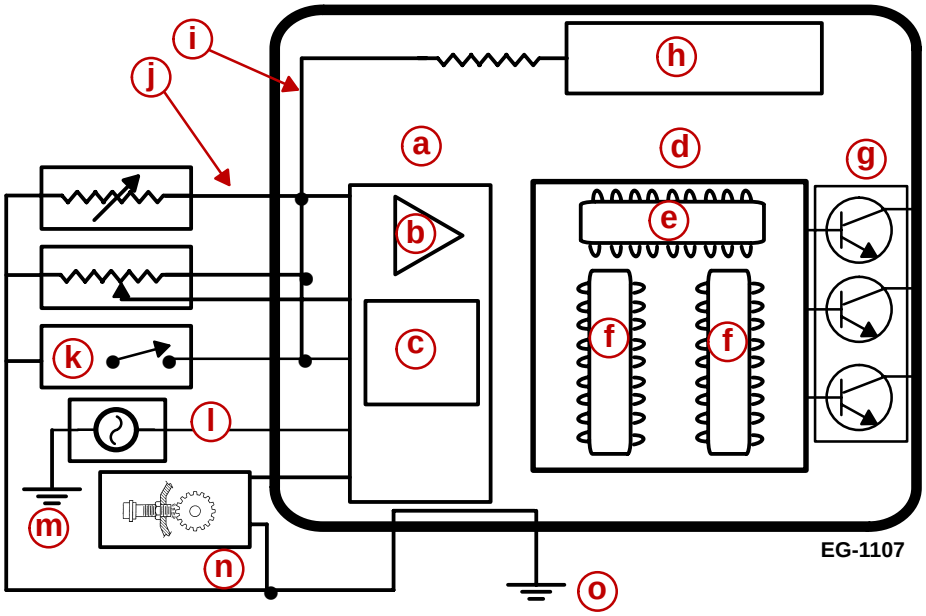
Input Signals

Engine and vessel sensors transmit input signals to the ECM by either:

- Controlling a reference voltage to produce an analog or digital signal (example - ICP, EOT).
- Generating a signal voltage (example - CMP).
- Switching a 12 volt signal (example - IVS).

Reference Voltage Sensors

Reference voltage sensors are supplied with a constant, regulated 5 volts from the ECM. A voltage regulator supplies the reference voltage (V Ref) to these sensors. This voltage is changed by the sensor and the signal is relayed back to the ECM. The ECM, then compares the supplied V Ref to the returned signal and determines the value of the variable being measured by matching the signal value with its internal programmed tables.



Types of Input Signals

a - Input Conditioner
b - Amplifiers
c - Analog to Digital Converter
d - Microcomputer
e - Microprocessor
f - Memory
g - Output Drivers
h - Reference Voltage Regulator
i - Reference Voltage (5 Volts) From Voltage Regulator
j - Signal Lines
k - Switch
l - Voltage Generator
m - Ground (–)
n - Magnetic Pickup
o - Signal Return Provided Through Processor

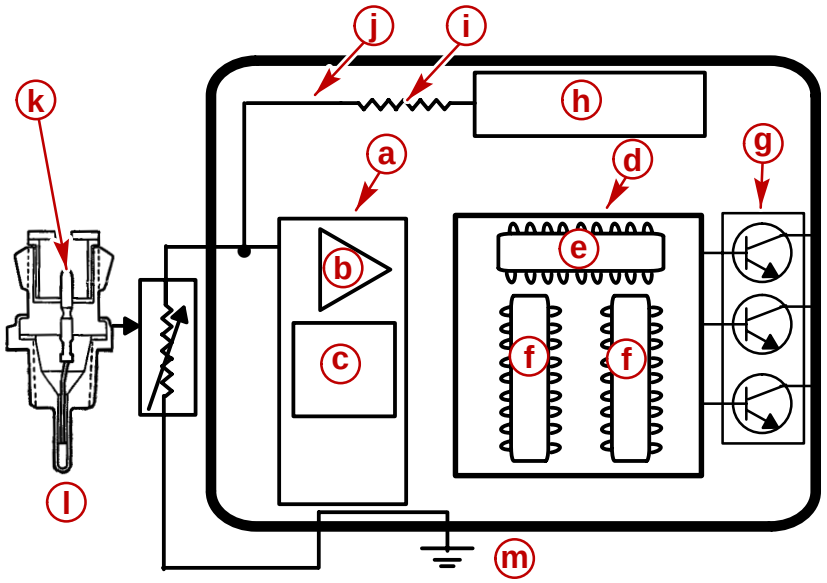
Thermistor

A thermistor is a type of sensor which changes it's electrical resistance when the temperature to which it is exposed changes. The electrical resistance of the thermistor decreases as temperature increases and increases as temperature decreases. The thermistor in conjunction with a current limiting resistor in the ECM forms a voltage divider network that provides a voltage signal indicating temperature.

The top half of the voltage divider is the current limiting resistor internal to the ECM. A thermistor sensor has two electrical connections, signal return and ground. The analog output signal of a thermistor sensor is not linear.

Examples:

EOT	Engine Oil Temperature
ECT	Engine Coolant Temperature Sensor
IAT	Intake Temperature Sensor

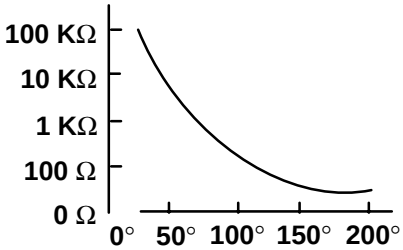


EG-1108

A Thermistor Circuit

- **a** - Input Conditioner
- **b** - Amplifiers
- **c** - Analog to Digital Converter
- **d** - Microcomputer
- **e** - Microprocessor
- **f** - Memory
- **g** - Output Drivers
- **h** - Reference Voltage Regulator
- **i** - Current Limiting Resistor
- **j** - 5 V Ref
- **k** - 2 Terminals -- V Ref Connection, Ground Connection
- **l** - ECT
- **m** - Signal Return Provided Through Processor

IMPORTANT: The chart indicates resistance (Ω) of a thermistor decreases as temperature (°) increases. Output of thermistor is not linear.

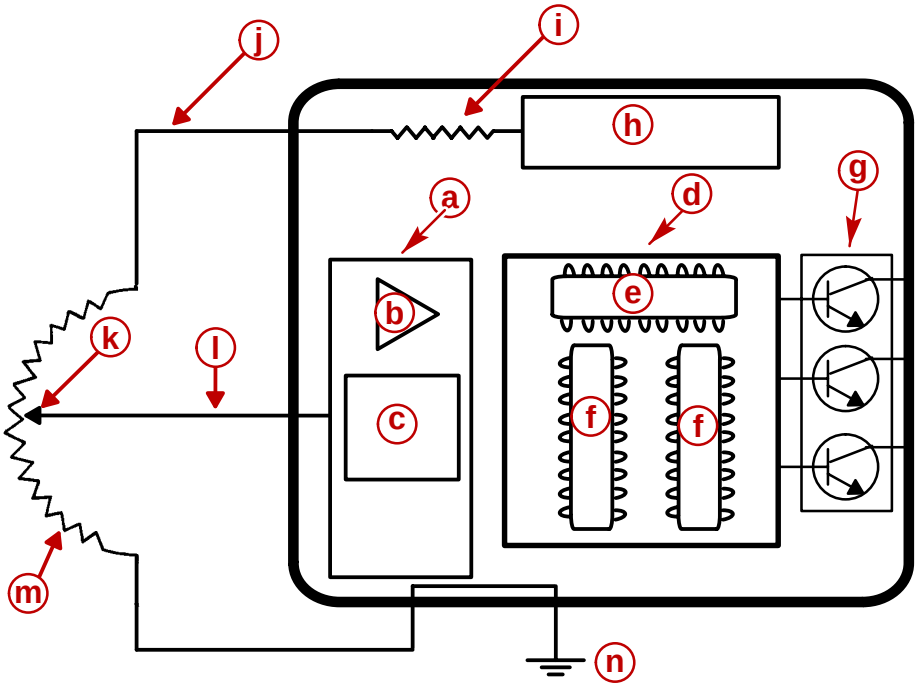


Potentiometer

A potentiometer is a variable voltage divider used to sense the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical motion connected to the wiper causes it to move along the resistance material in a rotary fashion.

The voltage on the wiper changes at each point along the resistive material. This voltage is proportional to the amount of mechanical movement.

Example: APS Accelerator Position Sensor



EG-1109

A Potentiometer Circuit

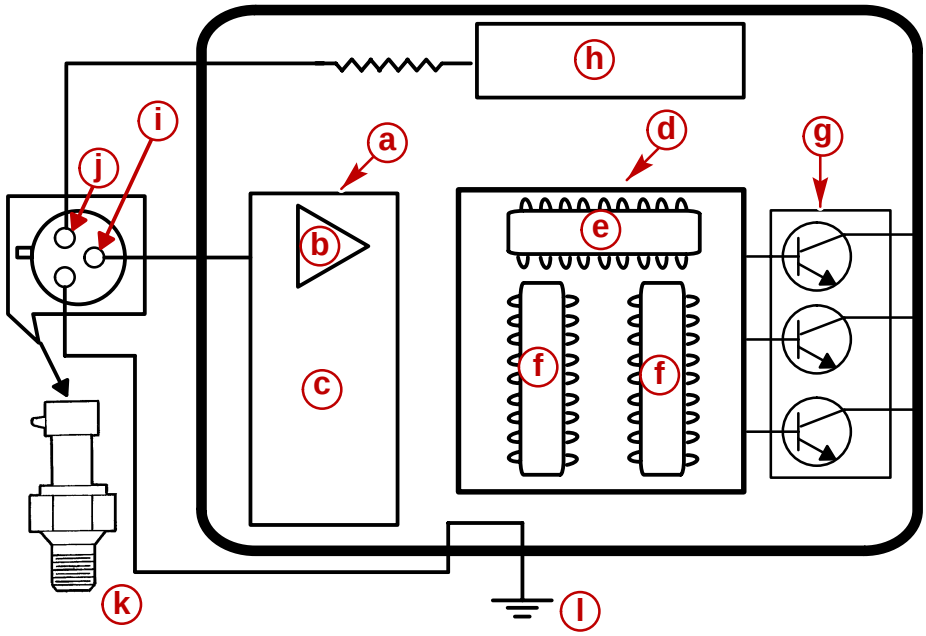
- **a** - Input Conditioner
- **b** - Amplifiers
- **c** - Analog to Digital Converter
- **d** - Microcomputer
- **e** - Microprocessor
- **f** - Memory
- **g** - Output Drivers
- **h** - Reference Voltage Regulator
- **i** - Current Limiting Resistor
- **j** - 5 V Ref
- **k** - Signal Voltage
- **l** - Movable Wiper
- **m** - Resistive Material
- **n** - Ground

Variable Capacitance Sensor

Variable capacitance sensors are used to measure pressure. The pressure which is to be measured is applied to a ceramic material. The pressure forces the ceramic to move closer to a thin metal disk. This action causes the capacitance of the sensor to change which creates a frequency that corresponds to a pressure.

The internal circuitry of the sensor converts that frequency into a linear analog voltage that indicates pressure. The thicker the ceramic disk the more pressure that sensor can measure. A variable capacitance sensor has three connections: V Ref, signal and ground.

Examples: EOP Engine Oil Pressure Sensor
ICP Injection Control Pressure Sensor



EG-1110

A Variable Capacitance Sensor Circuit

- **a** - Input Conditioner
- **b** - Amplifiers
- **c** - Analog to Digital Converter
- **d** - Microcomputer
- **e** - Microprocessor
- **f** - Memory
- **g** - Output Drivers
- **h** - Reference Voltage Regulator
- **i** - Signal Voltage
- **j** - V Ref
- **k** - EOP
- **l** - Ground

Hall Effect Sensor

The Hall Effect sensor is an electronic device which generates a voltage signal controlled by the presence, absence or strength of a magnetic field.

It contains a transducer, permanent magnet, signal conditioner and a switching transistor. The sensor's permanent magnet applies a magnetic field around the transducer as shown. The sensor's transducer senses the strength of the magnetic field which is controlled by the vanes and windows (located on the rotating timing sensor disk) as they pass the sensor.

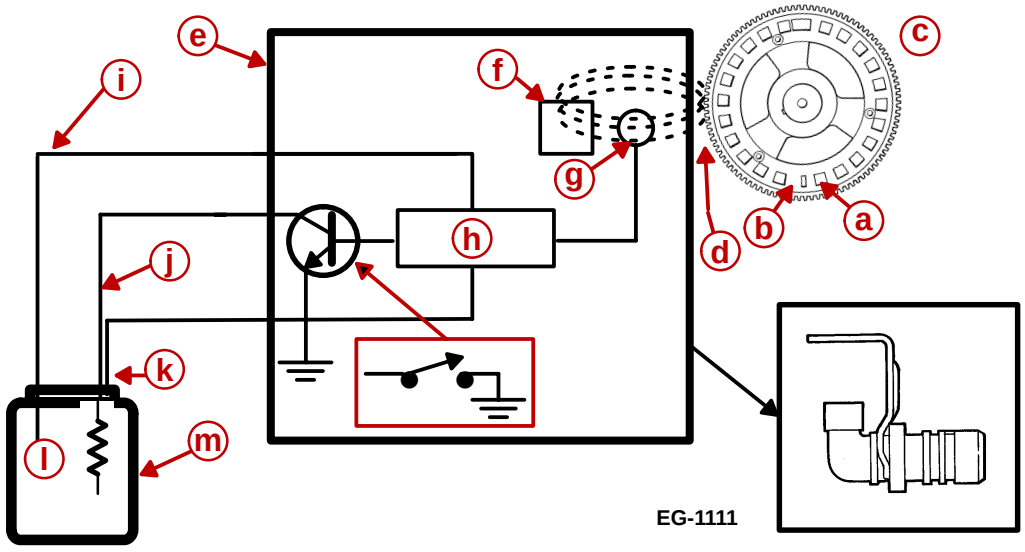
A voltage signal is generated by the Hall Effect device each time a window passes the device. The signal is filtered and conditioned by the signal conditioner. The conditioned signal is applied to the switching transistor's base which causes the transistor to switch on and ground the 5 volt line from the ECM. The ECM no longer senses the 5 volt reference signal.

Each time a vane passes the Hall Effect device no signal is generated. This action causes the transistor to shut off and causes the ECM to see its 5 volt reference signal.

This switching action allows the ECM to determine crankshaft position and engine speed which is required by the ECM to control engine operating parameters such as injector timing, injection duration (injection pulse width) and Injection Control Pressure.

The sensor is connected to the ECM by three wires: a 5 volt signal supply, a 5 volt power feed for the signal conditioner VDREF and signal ground (–).

Example: CMP Camshaft Position Sensor



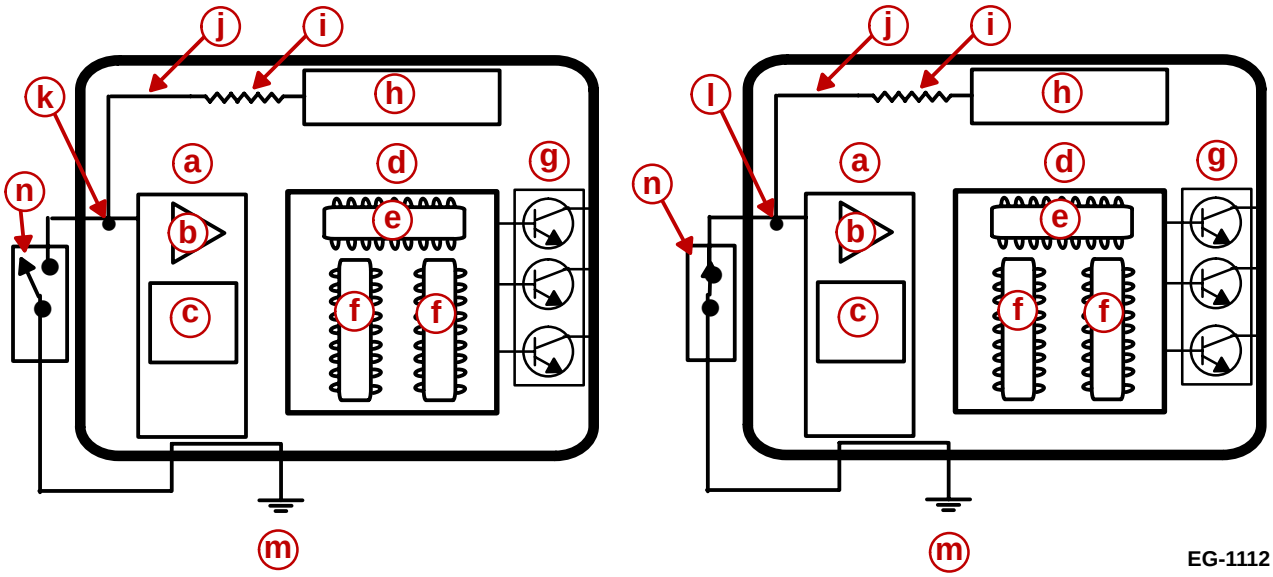
a - Window
b - Vane
c - Timing Sensor Disk (Located On Face Of Camshaft Gear)
d - Air Gap
e - Hall Effect Sensor (Camshaft Position Sensor)
f - Permanent Magnet
g - Transducer
h - Signal Conditioner
i - Power Supply For Sensor(5 Volt Reference From ECM)
j - 12 Volts From ECM
k - CMP Ground
l - Internal Pull Up Resistor
m - ECM

Switch Sensors

Switch sensors are used to indicate position or pressures. The signal of a switch sensor is a digital signal created by either opening or closing a switch. The on or off signal can indicate position as in the case of an idle validation switch or pressure as in the case of a low oil pressure switch. A switch sensor can be either a voltage input type switch or a grounding type switch.

A voltage input style switch will supply the ECM with a voltage when closed. A grounding type switch is wired in series with a current limiting resistor in the ECM and will cause a zero voltage signal when closed (grounding the circuit). A switch sensor normally has two connectors signal return (Ground) and the signal. A switch sensor is considered a low speed digital input.

Example: IVS Idle Validation Switch



Switch Open **Switch Closed**

a - Input Conditioner
b - Amplifiers
c - Analog to Digital Converter
d - Microcomputer
e - Microprocessor
f - Memory
g - Output Drivers
h - Reference Voltage Regulator
i - Current Limiting Resistor
j - 5 V Ref
k - High Voltage Signal (5 Volts) To Input Conditioners
l - Low Voltage Signal (Less Than 1 Volt) To Input Conditioners
m - Signal Return Provided Through Processor
n - Switch

Standard Features

Electronic Governor Control

All D7.3L D-Tronic engines are electronically governed over all operating ranges.

Glow Plug Assisted Start

This feature increases engine start-ability in cold weather. The glow plugs are controlled by the Electronic Control Module which monitors engine temperature. A Pre-Heat Indicator Lamp (sometimes called the “WAIT TO START“ lamp) is included to inform the operator when the engine is ready for cranking.

ATA Data Link

The engine is equipped with an ATA (American Trucking Association) data link connector that allows communication between the electronic engine control system and the Pro-Link® 9000 Electronic Service Tool (EST).

The data link provides communication capabilities for:

- Engine parameter data transmission.
- Diagnostics and troubleshooting.
- Production line programming of vehicle features.

Service Diagnostics

The electronic service tool provides means for obtaining diagnostic information using the ATA data link. The recommended electronic service tool is the Pro-Link® 9000 with an International cartridge. Sensor, actuator, electronic component and engine system faults can be detected by the ECM and be diagnosed by the EST.

The engine control system also provides service diagnostic information via flash codes emitted using the engine warning lamp. The service literature is indexed according to the flash codes.

Engine Over-Temperature Protection

This system reduces fuel delivery when the engine coolant temperature is above the cooling system design target value. Fueling is reduced proportionally to the extent the design limit is exceeded. The reduction is calibrated to a maximum of 20% before standard engine warning and/or optional warning/shutdown systems engage. If this feature is activated, a fault code is stored in the Electronic Control Module’s memory to explain low power complaints.

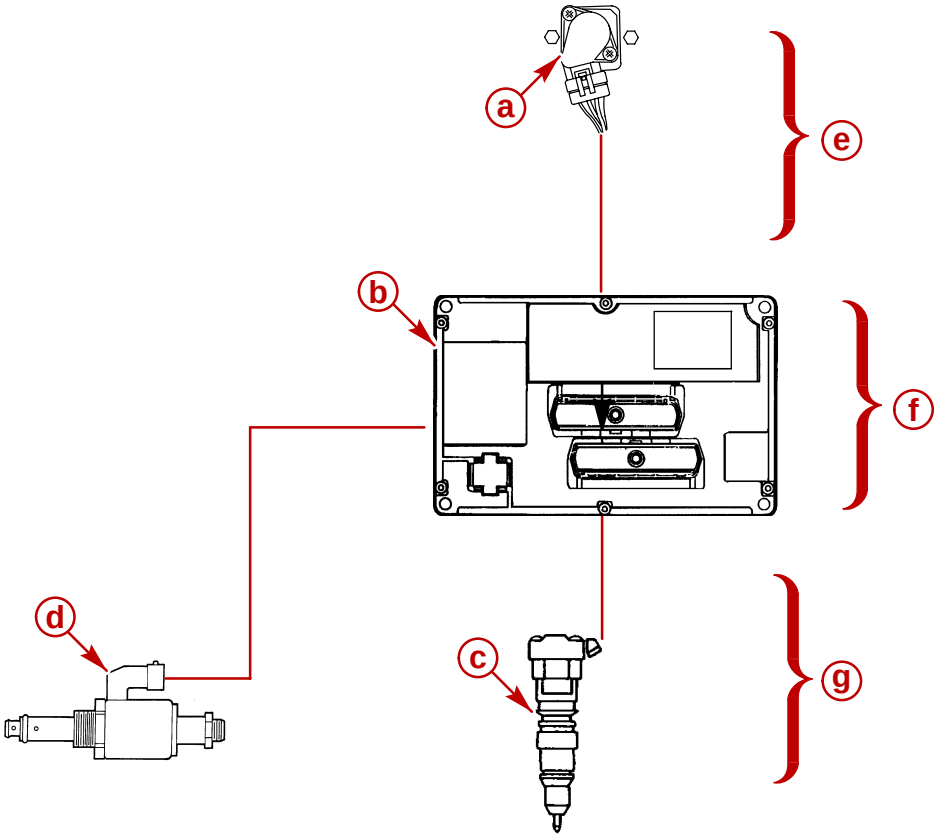
Event Logging System

This system records if the engine was operated beyond maximum rpm, over heated (coolant temperature), low on coolant and/or experienced low oil pressure. This information is stored in the ECM memory and may be accessed through the use of the EST.

Electronic Throttle Position

An accelerator position sensor provides the ECM with an analog voltage signal representing the operator's demand for power.

The input signal is processed by the ECM resulting in specific output signals to the various components causing the engine to increase power.



Electronic Throttle System

- **a** - APS
- **b** - ECM
- **c** - Fuel Injector
- **d** - IPR
- **e** - Input
- **f** - Processing
- **g** - Outputs

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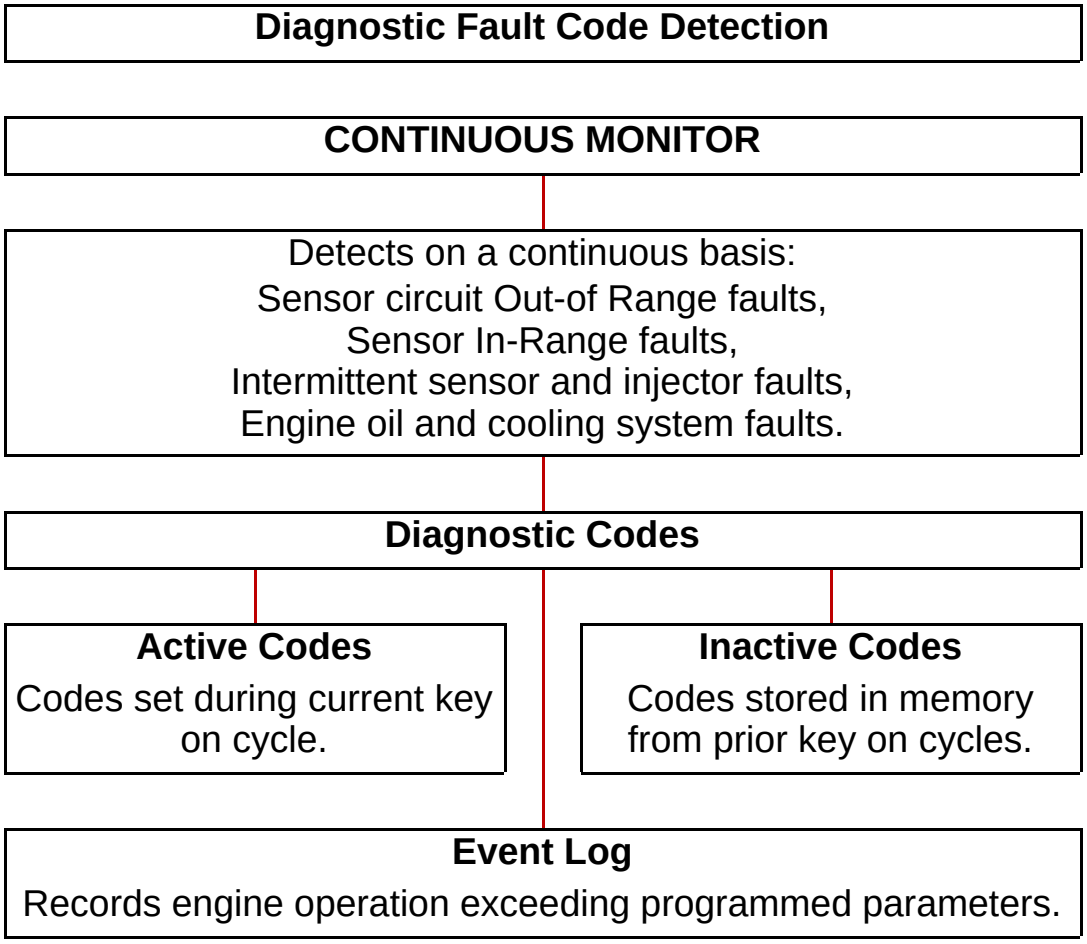
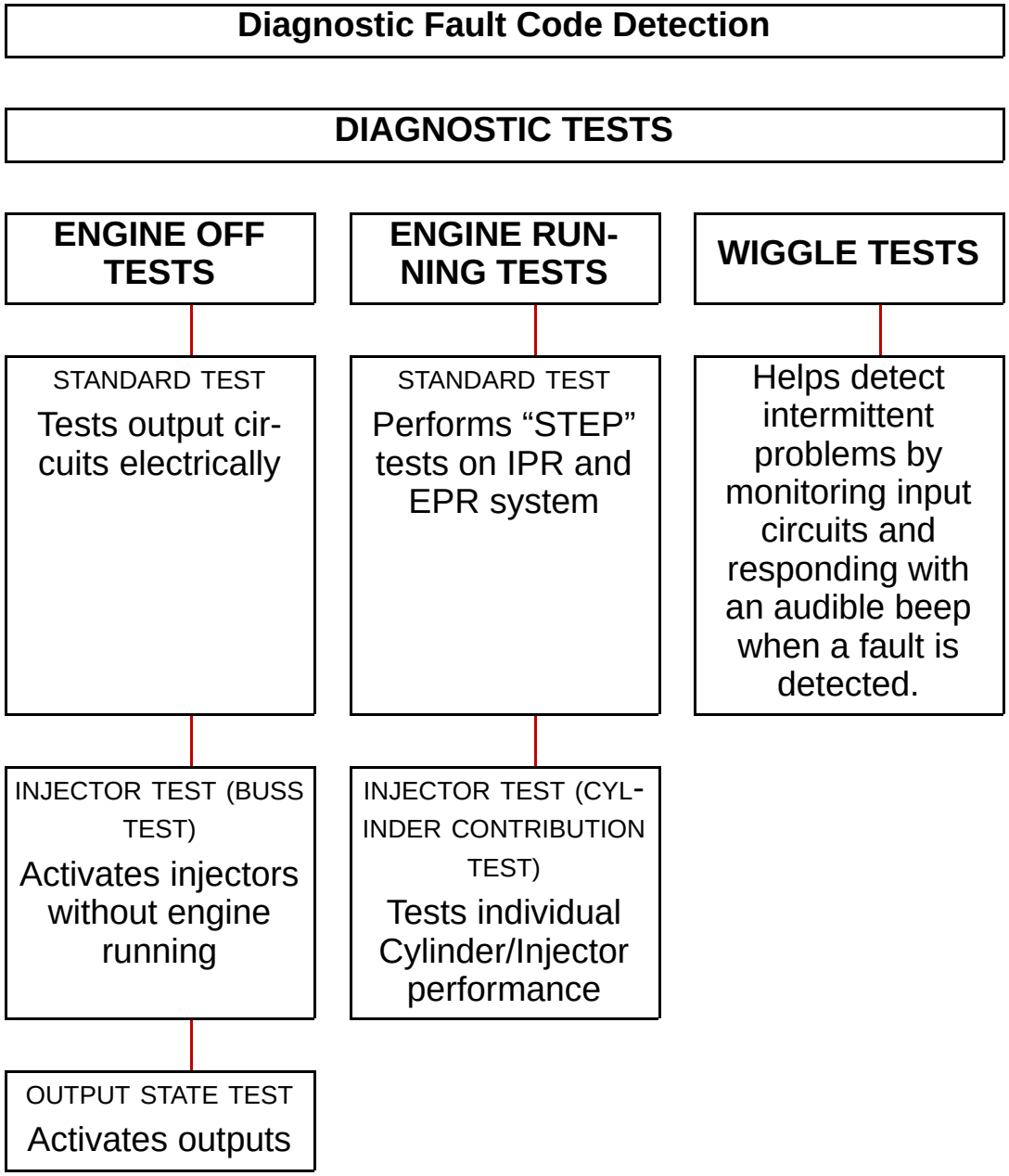
Diagnostic Software Self Test Operation

Test Chart


Diagnostic Fault Code Detection
CONTINUOUS MONITOR
Detects on a continuous basis:
Sensor circuit Out-of Range faults,
Sensor In-Range faults,
Intermittent sensor and injector faults,
Engine oil and cooling system faults.
Diagnostic Codes
Active Codes
Codes set during current key on cycle.
Inactive Codes
Codes stored in memory from prior key on cycles.
Event Log
Records engine operation exceeding programmed parameters.

Diagnostic Software Self Test Operation(Continued)

Test Chart (Continued)


Diagnostic Fault Code Detection
DIAGNOSTIC TESTS
ENGINE OFF TESTS
ENGINE RUN-NING TESTS
WIGGLE TESTS
STANDARD TEST
Tests output cir-cuits electrically
STANDARD TEST
Performs “STEP” tests on IPR and EPR system
Helps detect intermittent problems by monitoring input circuits and responding with an audible beep when a fault is detected.
INJECTOR TEST (BUSS TEST)
Activates injectors without engine running
INJECTOR TEST (CYL-INDER CONTRIBUTION TEST)
Tests individual Cylinder/Injector performance
OUTPUT STATE TEST
Activates outputs

Continuous Monitor

Diagnostics are performed by the Electronic Control Module (ECM) continuously to detect out of range, rationality and system faults.

During the time that the key is in the “RUN” (ON) position, if an input signal is “Out of Range” meaning the signal is either greater or lesser than what the signal range should be during normal operation, the ECM will record a “Fault.” It will also monitor the operation of systems and will determine if the system is working within a normal range. If the ECM detects that a system falls outside a predetermined range, it will record and flag a fault.

During normal engine operation, the ECM automatically performs several tests to detect faults. When it has detected a fault, the ECM often invokes a fault management strategy to allow continued, though sometimes degraded, engine operation.

A “Fault” is an indication of a malfunction measured or monitored electronically. Sometimes “Faults” are referred to as “Codes.”

“Codes” are three digit numbers assigned to Faults to indicate the source of the malfunction. Most Codes will indicate the source and the “Mode” of failure. The “Failure Mode” will indicate the signal reading, i.e.: “Out of Range High,” “Out of Range Low” or in Range fault.

During operation with the engine running, the ECM memory will record “EVENT ENGINE HOURS.” This is the monitoring of engine operation exceeding programmed parameters. The standard Engine Event is Overspeed of the engine, referred to as Over RPM and excess coolant temperature. To retrieve information on Engine Events, it will be necessary to access them with the Electronic Service Tool.

If the engine is equipped with the optional engine warning/shutdown system, low oil pressure, will also be monitored and recorded as “EVENT ENGINE HOURS.”

Operator “On Demand” Tests (Engine Off)

“Engine Off Tests” are “Standard Tests” performed by the ECM. These tests are commanded by the operator using the Electronic Service Tool (EST) or the Audio Test switch to initiate a Self Test Input (STI) diagnostic test.

To use the EST, access the Engine menu and select Diagnostic Tests. Then select “Engine Off Tests.” Depressing the Enter key will initiate the test.

To initiate an STI test, push the Audio Test switch toggle lever DOWN, while turning the ignition switch to the “RUN” (ON) position. **Do not start the engine.** Release the Audio Test switch lever.

When the operator signals the test to begin, the ECM will perform internal tests of its processing components and internal memory.

It will automatically proceed to Output Circuit Check (OCC). This will operate the ECM output circuits. It will measure each individual circuit’s response. The following circuits are checked by the ECM during the test:

- Injection Pressure Regulator (IPR)
- Glow Plug Control (relay)
- OIl Pressure Warning Lamp
- Coolant Temperature Warning Lamp
- Glow Plug (Preheat Indicator) Lamp

The ECM will monitor the outputs and test the operation of the output signals and actuators. If a circuit fails the test, a fault code will be logged.

When the test is complete, the EST will display any faults that were found during the test. If the STI diagnostic test was used, the faults will be transmitted as “Flash Codes,” using two of the Engine System Monitor lamps.

The fault codes are read by counting the number of light flashes. The following sequence occurs:

1. The **“COOLANT TEMPERATURE”** lamp will flash one time. This indicates the beginning of Active Fault Codes.
2. The **“CHECK ENGINE”** lamp will flash repeatedly signaling the active fault codes. All codes are three digits. The number of flashes should be counted in sequence.
3. At the end of each digit of the code there will be a short pause. Three flashes and a pause indicates the number 3. The code 232 will be sent as two flashes, (a pause), three flashes, (a pause), and two flashes.

If there is more than one code being sent, the **“COOLANT TEMPERATURE”** lamp will flash once indicating the beginning of another active fault code. The code 111 indicates “NO FAULTS”.

If no further Active Fault Codes exist, the **“COOLANT TEMPERATURE”** lamp will flash twice, indicating the beginning of inactive Codes. The **“CHECK ENGINE”** lamp will then flash the Inactive Code(s) present. If several Inactive Codes are present, the **“COOLANT TEMPERATURE”** light will flash once between each of the fault codes.

When all of the stored fault codes have been sent, the **“COOLANT TEMPERATURE”** lamp will flash three times indicating “END OF MESSAGE”.

If it is necessary to repeat transmission of fault codes, push the Audio Test switch toggle lever down and all stored codes will be transmitted again as described previously.

The STI test procedure can be modified and utilized to clear the Diagnostic Codes by:

1. Pushing and holding the Audio Test switch toggle lever down.
2. Turn the key switch to “RUN” (ON).
3. Move the throttle lever to WOT and back to idle three times.
4. Release the Audio Test switch lever.

INJECTOR BUZZ TEST

The purpose of the Engine Off Injector “BUZZ” Test is to diagnose electrical problems with the fuel delivery components. This test can only be accessed with the EST and only after an “Engine Off Test” or Self Test has been performed.

NOTE: *Before running this test, fault codes should be accessed, noted and erased. This will allow the faults found in this test to be displayed as “ACTIVE CODES.”*

During the test, the ECM will activate the injectors in numerical order 1 thru 8. The ECM will monitor each injector’s electrical circuit operation. The ECM will receive feedback signals which indicate the status of injector performance and electrical circuit operation. If an electronic component in the fuel system fails the parameters of the test, an inactive fault code will be logged and transmitted to the EST at the end of the test.

NOTE: *The technician can monitor injector operation by listening to the sound each injector produces as it is activated by the ECM, however, in a hard start/no start condition where the oil may be very cold/thick, injectors may not be audible.*

If the faults were not erased before this test, the faults found during this test will be displayed as “INACTIVE CODES.”

To read these fault codes, access the “Diagnostic Codes” menu and read both Active and Inactive codes.

OUTPUT STATE TEST

The purpose of the Output State Test is to diagnose the operation of the output signals and actuators. This test can only be performed by using the Electronic Service Tool.

To run this test, select the Output State Test from the EST Engine Off Test menu. The test consists of two modes of operation:

1. Toggling outputs from high to low.
2. Toggling outputs from low to high.

When in the **"OUTPUTS ARE LOW"** mode the ECM will pull down the output voltage to their low state. This will actuate the output components that are controlled by the ECM grounding the circuits. During this test **"OUTPUTS ARE LOW"** will be displayed on the screen.

When in the **"OUTPUTS ARE HIGH"** mode the ECM will pull up the output voltage to their high state. This will actuate the output components that are controlled by the ECM energizing the control circuits. During this test **"OUTPUTS ARE HIGH"** will be displayed on the screen.

During this test, the output of the circuit in question can be monitored with a DVOM. The DVOM will measure a "High or Low" voltage state condition as the outputs are toggled. The actual voltage will vary with the circuit tested.

NOTE: *The EST will only display "outputs Are High" or "Outputs Are Low". It will not display any voltages, etc. A DVOM is required to monitor the suspected problem circuit or actuator.*

NOTE: *Faults will not be set during this test.*

This following actuators and signals are toggled high and low during the test:

- Injection Pressure Regulator
- Glow Plug Lamp
- Oil Pressure Warning Lamp
- Coolant Temperature Warning Lamp
- Check Engine Lamp

Operator “On Demand” Tests (Engine Running)

STANDARD TEST

The Self Test (Engine Running) checks the operation of the Injection Pressure Regulator (IPR).

During the test, the ECM commands the IPR actuator through a pre-programmed testing sequence to determine if the actuators are performing as expected. The ECM monitors the feedback signal values from the injection control pressure sensor and compares that value to the expected value. At the end of the test, the ECM will return the engine to the normal operating mode and transmit any fault codes which may have been set during the test.

This test can only be performed by using the Electronic Service Tool.

Procedure

NOTE: *Engine coolant temperature must be 160°F, battery voltage must be higher than 12.5 volts. If Active Fault Codes are present, they must be repaired and cleared prior to running this test.*

1. Select **“**Engine Running Test” from the **“Diagnostic Test”** menu in the EST.
2. Press **“ENTER”** to begin test. The ECM will begin to raise the engine idle speed to a predetermined value. It will then command the IPR valve to set the injection control pressure to rated speed pressure. If the performance of the IPR is acceptable,the ECM will control the IPR valve to reduce the pressure in steps while continuing to monitor the performance of the injection control pressure system.

When testing is completed, normal engine operation is restored and fault codes will be transmitted as described previously.

INJECTOR TEST “CYLINDER CONTRIBUTION”

The Injector Test is designed to detect problems with injection and combustion events. During the test the ECM will control fuel delivery and determine each cylinder’s power contribution. If a cylinder is not performing satisfactorily, a fault code will be set.

This test can only be performed by using the Electronic Service Tool.

Procedure

NOTE: *The engine running self test must be performed first in order to gain access to the injector (engine running) test in the EST.*

1. Select Injector Test from the Engine Running Test menu.
2. The ECM will increase the normal amount of fuel delivery (over-fuel) to the injector/cylinder being tested and monitor the reduction of fuel required to operate the remaining injectors to maintain engine speed. If there is no reduction in fuel delivery to the other cylinders the ECM will set a fault code identifying the non-contributing cylinder.

When testing is completed, normal engine operation is restored and fault codes will be transmitted.

WIGGLE TEST

The purpose of the Wiggle Test is to troubleshoot intermittent connections at sensors and actuators. It may be performed with the engine off or running. The Electronic Service Tool is used to monitor the following circuits during the Wiggle Test:

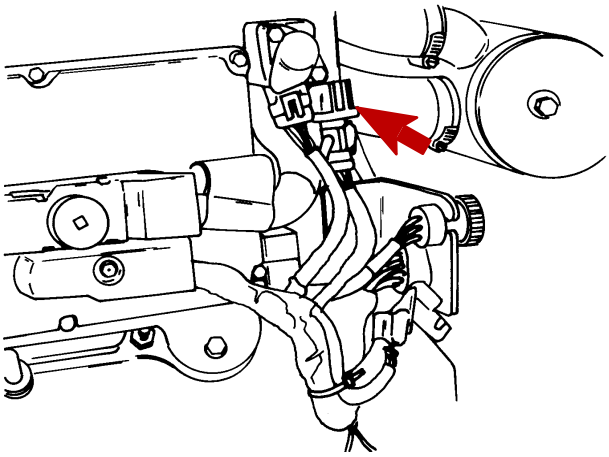
- Accelerator Position Sensor (APS)
- Intake Air Temperature Sensor (IAT)
- Camshaft Position Sensor (CMP)
- Data Communication Link
- Engine Coolant Temperature
- Engine Oil Pressure
- Injection Control Pressure
- Manifold Absolute Pressure
- Engine Oil Temperature

Procedure

1. Select the Wiggle Test from the “Diagnostic Test” menu in the EST. Press the **“ENTER”** key to begin test.
2. The technician should wiggle connectors and wires at all suspected problem points. The EST will **“BEEP”** if circuit continuity is broken. It will display all faults found during the test.

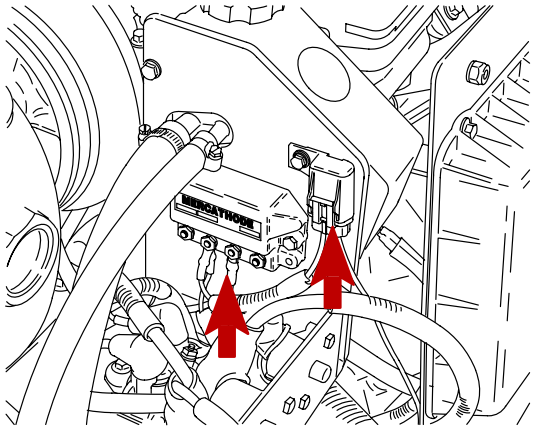
Sensor / Sender Locations

Relays



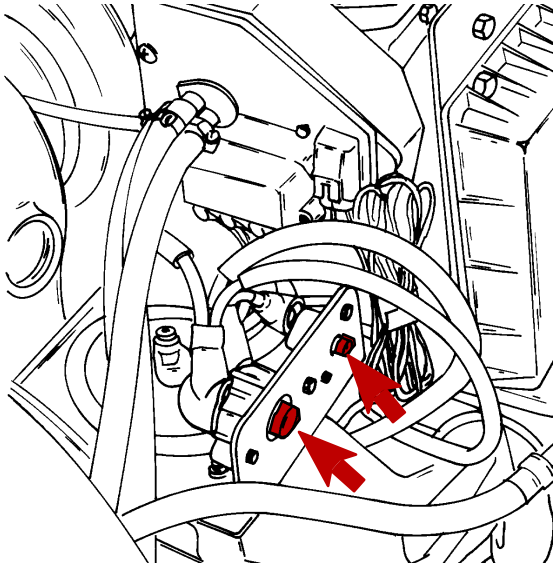
76013

MerCathode Controller And Fuse



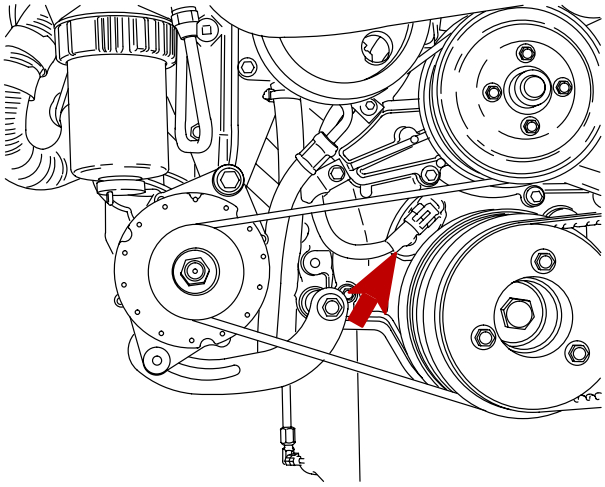
76134

Circuit Breakers



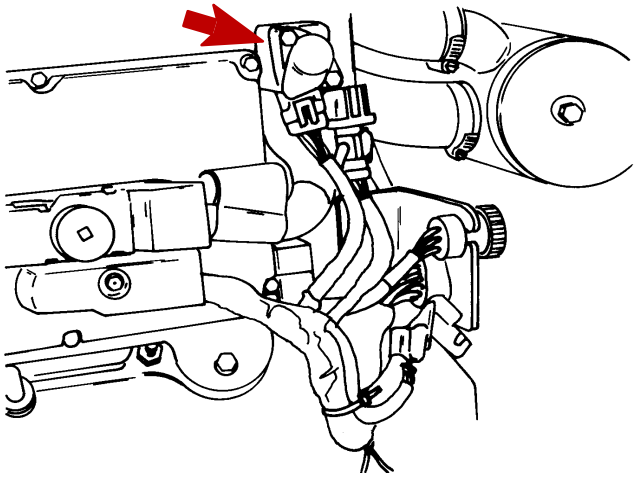
75955

Cam Position Sensor (CMP)



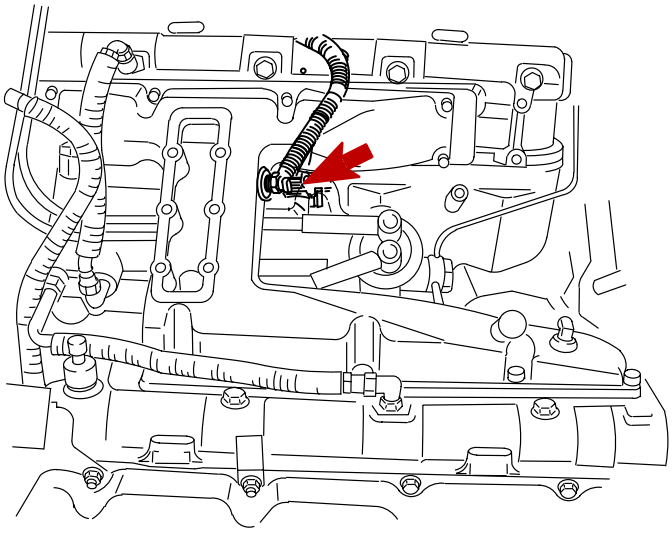
76117

Accelerator Position Switch / Idle Validation Switch (APS / IVS)



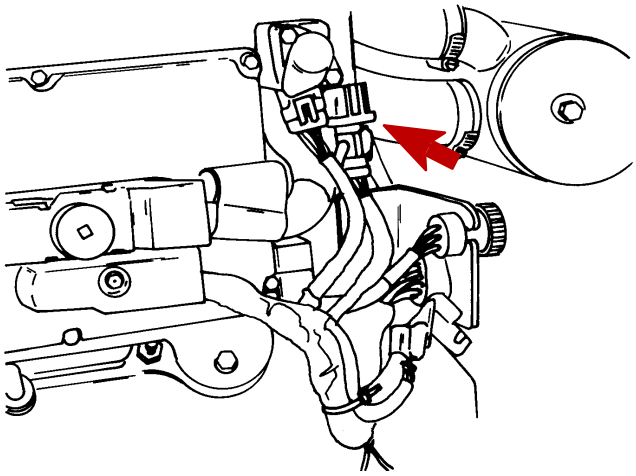
76013

Manifold Absolute Pressure (MAP) Sensor



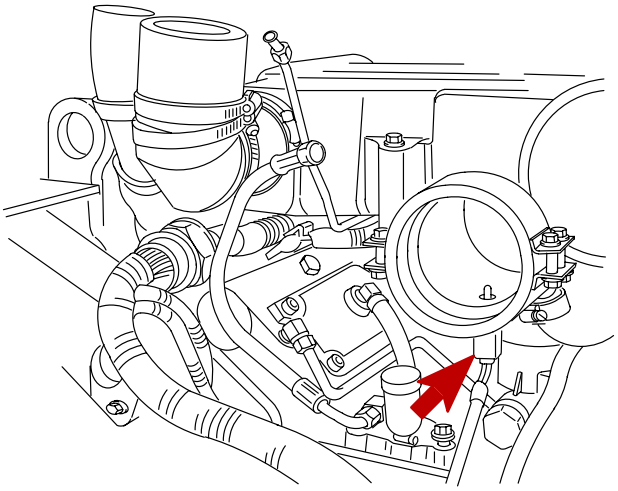
76181

Barometric Pressure (BARO) Sensor



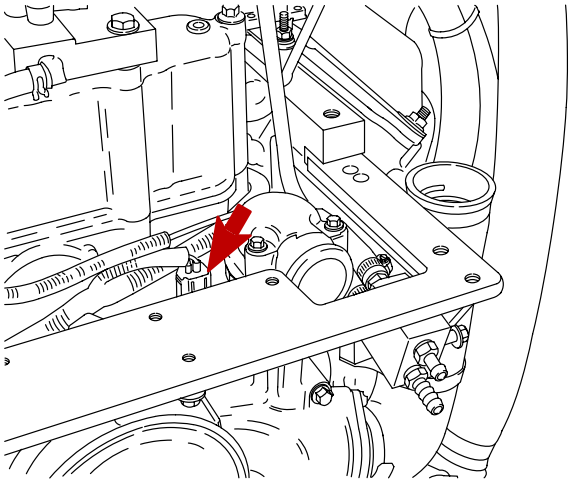
76013

Intake Air Temperature (IAT) Sensor



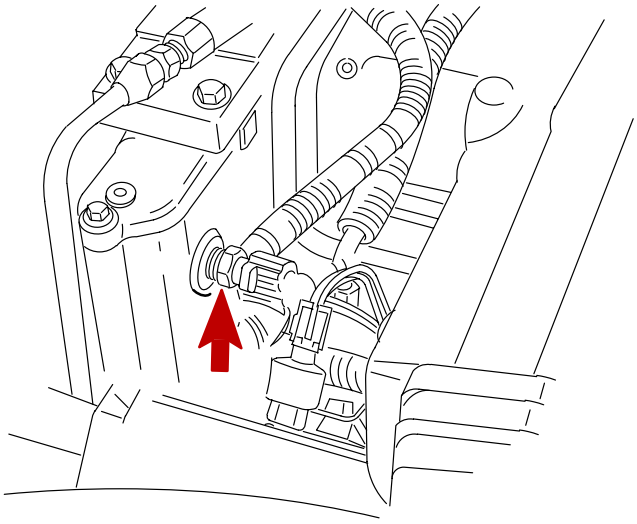
76149

Engine Coolant Temperature (ECT) Sensor



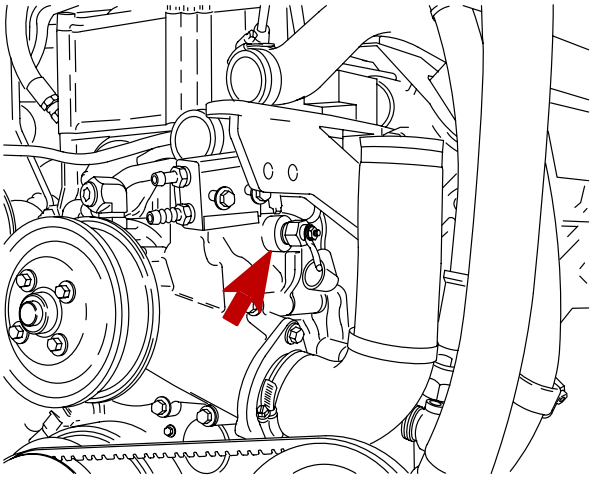
76141

Engine Oil Temperature (EOT) Sensor



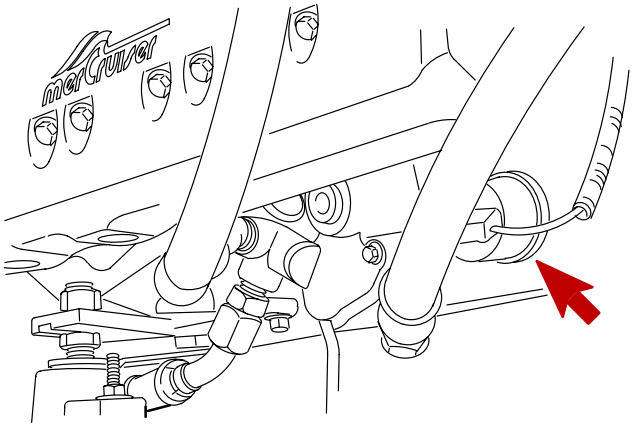
76152

Coolant Temperature Sender (To Gauge)



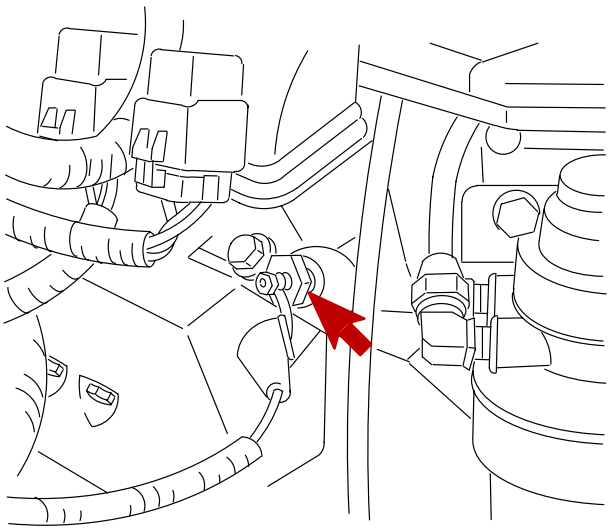
76156

Oil Temperature Sender (To Gauge)



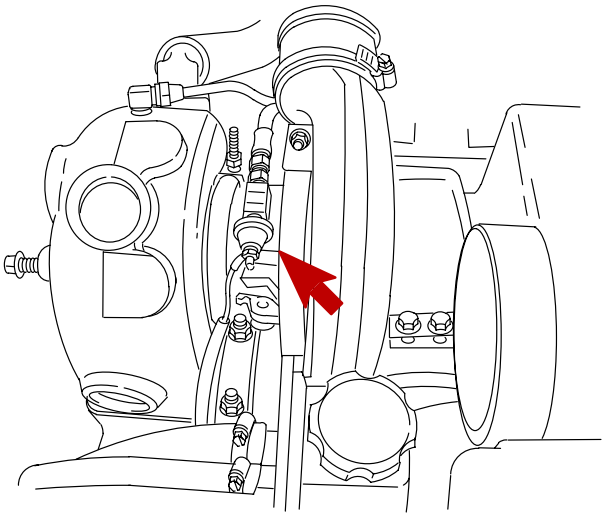
76157

Coolant Temperature Switch (To Alarm)



76209

Oil Temperature Switch (To Alarm)



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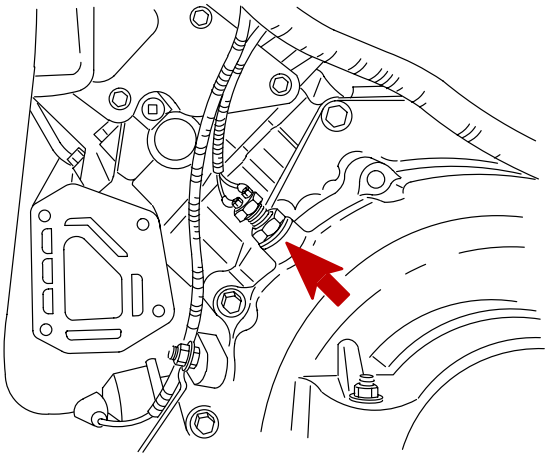
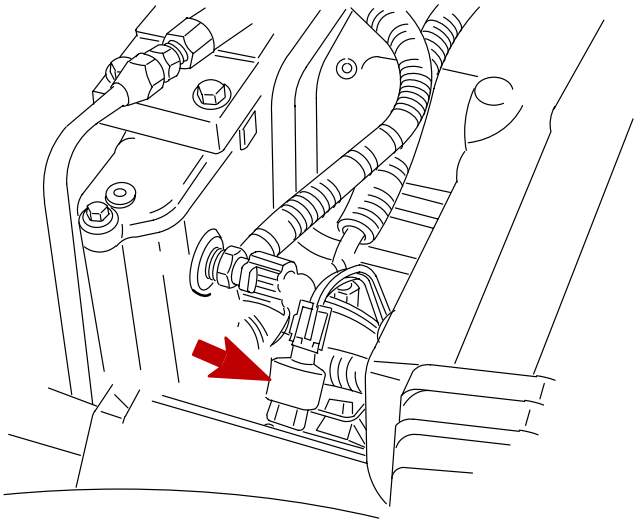
Tachometer Pickup



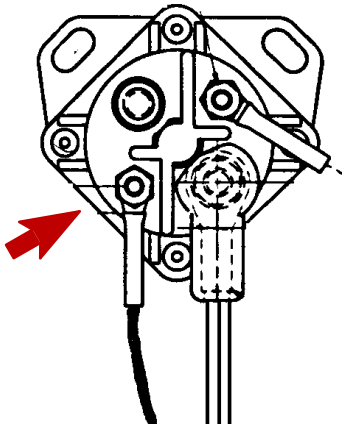
76148

Injection Control Pressure Sensor (ICP)

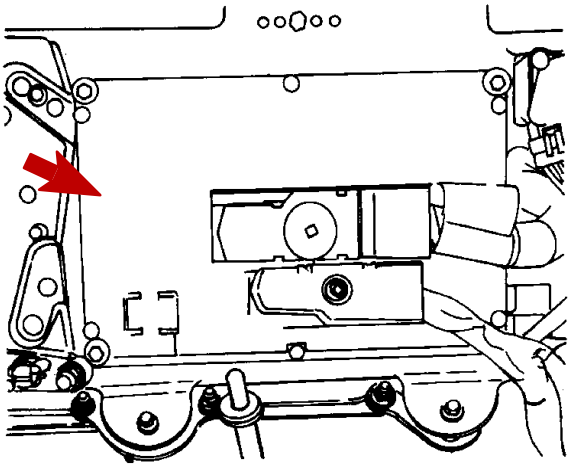


76152

Glow Plug Solenoid



Electronic Control Module (ECM)



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FUEL SYSTEM

Section 5B - Mechanical Diagnostics

Table of Contents

Hard Start / No Start Diagnostics 5B-2
Sufficient Clean Fuel 5B-2
Visual Inspection 5B-3
Checking Engine Oil Level 5B-5
Intake/Exhaust Restriction 5B-7
EST Tool Fault Codes 5B-8
EST Tool - Engine Off Tests 5B-11
EST Tool - Injector Buzz Test 5B-13
STI (Audio Test) Switch - Flash Codes 5B-14
EST Tool - Data List 5B-16
ECM Voltage 5B-19
Engine Cranking RPM 5B-21
Injection Control Pressure 5B-23
High Pressure Leakage Tests 5B-25
Fuel Pump Pressure 5B-29
Glow Plug System 5B-31
Performance Diagnostics 5B-34
Check Engine Oil Level 5B-34
Sufficient Fuel / Pressure 5B-35
Transfer Pump Restriction Test 5B-37
EST Tool Fault Codes 5B-39
EST Tool - Engine Off Tests 5B-41
EST Tool - Injector Buzz Test 5B-43
STI (Audio Test) Switch - Flash Codes 5B-44
EST - Engine Running Test 5B-46
EST Tool - Injector Test 5B-48
Fuel Pressure - Full Load 5B-50
Injection Control Pressure Test 5B-52
Fuel Pressure High Idle 5B-56
Fuel Pressure - Fuel Regulator Valve . 5B-58

Hard Start / No Start Diagnostics

Sufficient Clean Fuel

SUFFICIENT CLEAN FUEL

- Check at tank(s), drain sample from fuel filter while cranking engine.

Method	Check
Visual	

PURPOSE

To determine if the fuel system is getting sufficient clean fuel to start and operate the engine.

TEST PROCEDURE

1. Route a hose from the fuel drain tube to a clear container and open the drain.
2. Crank the engine and observe the fuel flowing into the container. Stop cranking the engine when the container is half full.

Fuel flow out of the drain tube should be a steady stream. Insufficient flow could indicate fuel supply or fuel system problem.

3. Inspect fuel in container. It must be clean and free of air, contaminants, water, icing or clouding. The fuel should be straw colored.
4. Check fuel odor for the presence of other fuels such as gasoline or kerosene.

If engine oil is present in the fuel, it may indicate an injector O-ring leak and subsequent loss of injection control pressure. If that is suspected, check the injection control pressure during engine cranking. Use the Electronic Service Tool (EST) or follow the procedure outlined later in this section.

NOTE: *Some sediment and water may be present in the fuel sample if the fuel filter has not been serviced or drained for a prolonged period of time. A second sample may be required to determine fuel quality.*

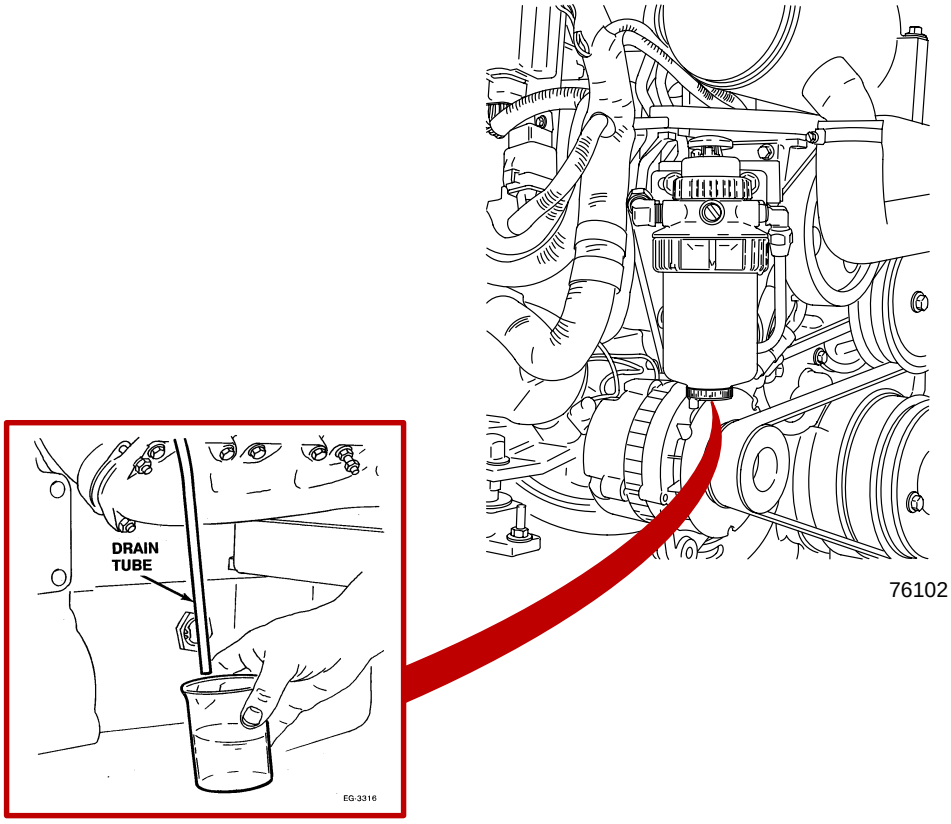
LOW OR NO FUEL - POSSIBLE CAUSES

- No fuel in tank.
- If equipped with an in line fuel valve, it could be shut off.
- Fuel supply line from tank(s) could be broken or crimped.
- Fuel could be waxed or jelled (most likely in cold weather with #2 fuel), the pickup tube in tank could be clogged or cracked. If there is excessive water in the tank, it could freeze preventing the fuel from being drawn to the engine.
- If the vessel is equipped with supplemental filters or water separators, check for plugged filters or leakage that could allow the fuel system to draw air.
- Cloudy fuel indicates that the fuel may not be a suitable grade for cold temperatures. Excessive water or contaminants in the fuel may indicate that the tank and fuel system may need to be flushed and cleaned.

Sufficient Clean Fuel (Continued)

TOOLS REQUIRED

Clear container [approximately 1 quart (1 L)].



Checking For Clean Fuel

VISUAL INSPECTION

VISUAL INSPECTION

Fuel Oil Coolant Electrical Air	
Method	Check
Visual	

PURPOSE

To check the general condition of the engine and to look for obvious causes of hard or no start conditions.

TEST PROCEDURE

1. Inspect entire fuel system for leaks including tank and lines. Inspect fuel lines for damage (kinks and bends).
2. Check high pressure oil lines and high pressure pump in engine “V” for major oil leaks.
3. Inspect entire cooling system, (coolant level in reservoir, hoses, water pump and heat exchange) for coolant leaks. Check for residue which may have been caused from prior leakage.
4. Inspect engine wiring harness for correct routing and insure that no rubbing or chaffing has occurred. Inspect the ECM connectors on the engine. Check connections to sensors, relays, actuators and control modules. Inspect battery cable connections for corrosion. **Check the fuses.** All connections should be seated and in good condition, free from damage and corrosion.

POSSIBLE CAUSES

- Loose or leaking fuel supply lines could cause fuel system to lose prime.
- Kinked or blocked fuel supply lines will create restriction to fuel flow.
- Massive fuel or oil leaks may contribute to no start conditions.
- Coolant leaks could indicate serious engine problems.
- Electronic connectors may be damaged or not installed properly causing a no start condition.

NOTE: *The Camshaft Position (CMP) sensor and the Injection Pressure Regulator (IPR) valve are the two most critical electronic components to inspect when the engine fails to start.*

TOOLS REQUIRED

Inspection light.

Checking Engine Oil Level

CHECK ENGINE OIL LEVEL

- Check for contaminants (fuel, coolant)
- Correct grade/Viscosity
- Miles/Hours on oil, correct level
- Check level in reservoir

Method	Check
Visual	

PURPOSE

To determine if the crankcase and oil reservoir contain engine oil of sufficient quantity and quality to enable the injection control pressure system to function properly.

TEST PROCEDURE

1. Check oil level with oil level gauge. If there is no oil or very little oil in the crankcase, the fuel injectors will not operate.

If the oil level on the gauge is over full, it is possible the engine was incorrectly serviced or fuel is diluting the oil and filling the crankcase. If a substantial amount of fuel is in the oil, it will have a fuel odor.

2. Inspect oil for color. A milky white oil indicates possible coolant contamination and will have an ethylene glycol odor.
3. Check service records for correct oil type and viscosity. Single weight or 15W-40 oil is not recommended for cold ambient temperatures. Oil that has had extended drain intervals will have increased viscosity (become thicker) and will make engine cranking more difficult and starting less reliable at temperatures below freezing. Refer to the lube oil chart in the operator's or service manual (SECTION 1B) for the correct oil selection for temperature conditions.
4. The oil level in the oil reservoir should be checked. Remove the inspection plug in top of reservoir to check oil level. Normal oil level is within 1/2 inch below the top of the reservoir. Normal oil level in the reservoir will allow the system to prime faster, facilitating starting.

If oil level in the reservoir drops while cranking the engine, it indicates that no oil is being pumped to the reservoir.

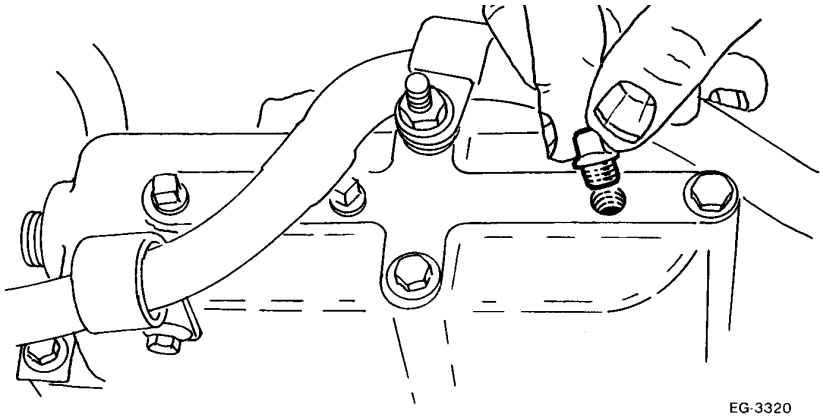
Checking Engine Oil Level (Continued)

POSSIBLE CAUSES

- Oil Level Low - Oil leak, oil consumption, incorrect servicing.
- Oil Level High - Incorrect servicing, fuel dilution from lift pump or defective injector O-rings.
- Oil Contamination With Coolant - Oil Cooler, head gasket, porosity.
- Low Reservoir Level - Engine built dry (not pressured lubed).

TOOLS REQUIRED

1/4” drive ratchet or breaker bar to remove inspection plug.



Removing Inspection Plug

Intake / Exhaust Restriction

INTAKE/EXHAUST RESTRICTION

- Inspect air filter and ducts
- Inspect exhaust system
- Inspect exhaust back pressure device

Method	Check
Visual	

PURPOSE

Visual inspection to determine if an intake or exhaust restriction is contributing to a “no start” or “hard start” condition.

NOTE: *A high intake or exhaust restriction may cause a considerable amount of black or blue smoke when starting the engine.*

VISUAL INSPECTION

1. Ensure air cleaner inlet is not restricted.
2. Ensure air cleaner housing, filter element and gaskets are properly installation.

NOTE: *Refer to performance diagnostics for detailed air cleaner restriction information.*

3. Inspect exhaust system for damaged or restricted pipes.

POSSIBLE CAUSES

- Foreign material may restrict air flow at the air cleaner inlet. On engines recently repaired, rags or cap plugs may have been inadvertently left in the intake system.
- The exhaust pipe may have been damaged or restricted.

TOOLS REQUIRED

None.

EST Tool Fault Codes

EST TOOL-FAULT CODES

- Install Electronic Service Tool
- Select Diagnostic Codes

Active	
Inactive	

PURPOSE

To determine if the Electronic Control Module (ECM) has detected any fault conditions that would cause a hard or no start condition.

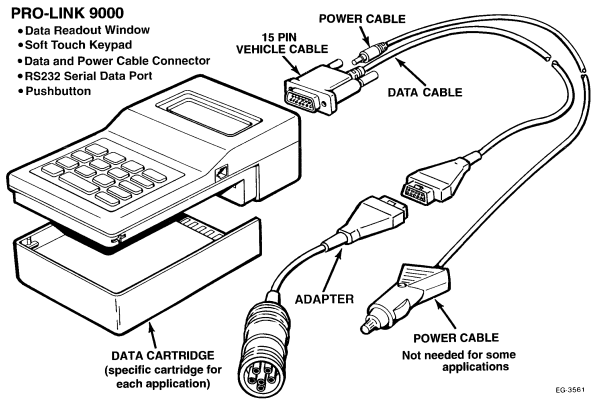
TEST PROCEDURE

NOTE: *Turn all accessories and the ignition OFF, before connecting EST tool to ATA (American Trucking Association) diagnostic connector.*

Connect the Electronic Service Tool (EST) to the ATA diagnostic connector. A connector is located on the engine and at the instrument panel.

The screen of the reader should light up as soon as the tool is plugged in.

NOTE: *The ATA connector supplies power to operate the EST. The EST will automatically power up as soon as it is plugged into the ata connector. The power cord is not required and is for use only when reading non-volatile memory.*



Turn the ignition switch to the RUN (ON) position, but **do not start** the engine. This will allow the EST to receive data from the electronic control components. If no data is received, press **"ENTER"** to retry. The information received will be data showing the current status of the engine.

To access the fault codes press the **"FUNC"** key to switch to the main menu.

MPSI PROLINK® MPC

– – – SELECTIONS – – –

NAVPAK™ MENU

From the main menu select **"ENGINE"** by pressing the "←" key. This will cause the brackets to be placed around the **"ENGINE"** selection. Then press **"ENTER."**

EST Tool Fault Codes (Continued)

From the next menu select "**DIAGNOSTIC CODES.**" The selection will have the "↑ ↓" symbol on the screen. This means there are other selections available. By pressing the "↓" key the other selections will display on the screen. Press "↓" key until **"DIAGNOSTIC CODES"** appears on the screen.

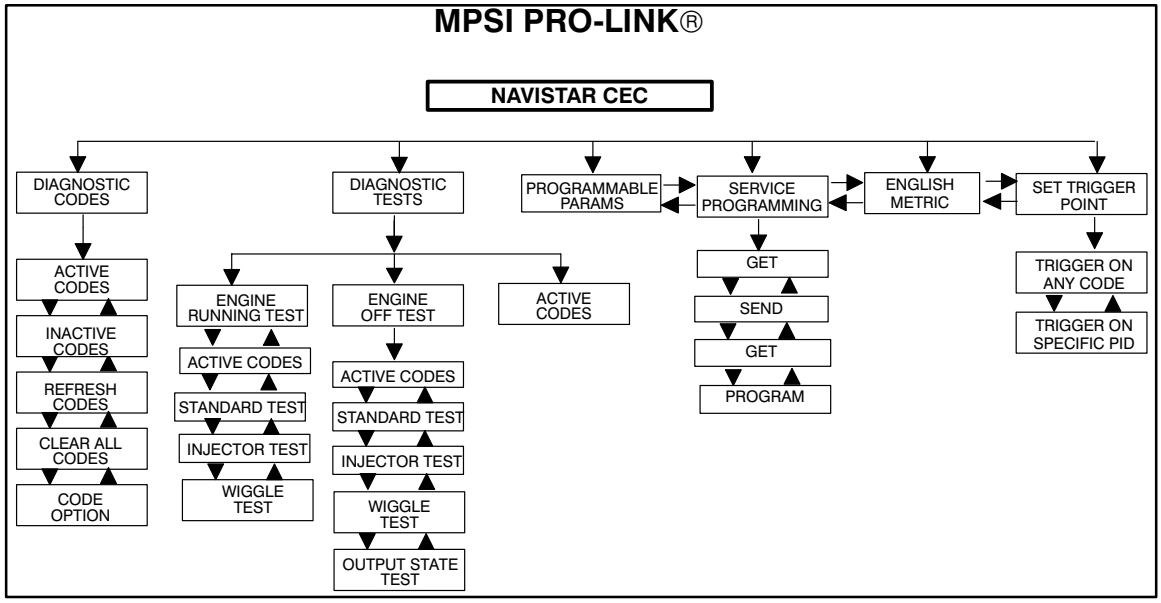
MAIN MENU
↑ – – – SELECTIONS – – – ↓
DIAGNOSTIC CODES

Next press **"ENTER."** This causes the EST to enter the diagnostic codes section. From this point, diagnostic codes can be accessed.

The first option that will appear is **"ACTIVE CODES."** By selecting this option, the fault codes that are currently occurring or that have occurred since the last key off cycle will be displayed.

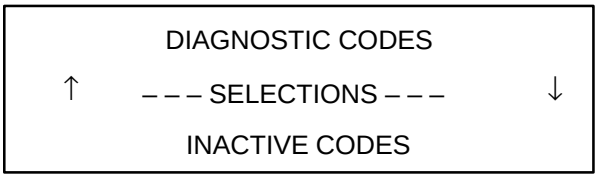
DIAGNOSTIC CODES
↑ – – – SELECTIONS – – – ↓
ACTIVE CODES

Press **"ENTER"**. If there are any "Active Codes," the first one will appear on the screen along with a description of the code. The number in the upper left hand corner represents the Flash Code number. This flash code number is referenced in the electronic diagnostic Flash Code Circuit Index (see Electronic Control System Diagnostics section). The numbers at the bottom of the screen represent the SAE codes. If there are any additional codes "Active" the "↑↓" symbol will appear on the screen. Press "↓" key to access additional codes. If there are not any codes "Active," **"EMPTY"** will appear on the screen.



EST Tool Fault Codes (Continued)

To access “Inactive Codes” press the **“FUNC”** key. This will access the last prior menu selection. Then press the “↓” key to select **“INACTIVE CODES.”** Press the **“ENTER”** key.



Inactive codes are faults that have occurred in the previous (ignition) “key ON cycles” and are now stored in memory. An “Active Code” will become an “Inactive” code when the key is shut off.

Record all fault codes that are found. If there are any fault codes found, refer to Electronic Control System Diagnostics section.

NOTE: *All current fault codes must be repaired and (cleared), before proceeding with further diagnostic testing.*

POSSIBLE CAUSES

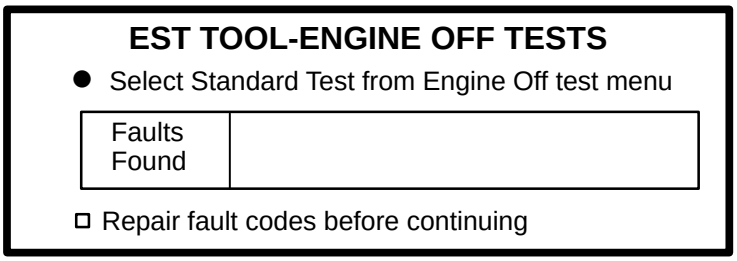
Electronic Control Module (ECM) detectable faults which will cause a hard or no start condition are:

- Camshaft Position (CMP) sensor inactive faults.
- Injection Pressure Regulator (IPR) output circuit check fault.

TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

EST Tool - Engine Off Tests


EST TOOL-ENGINE OFF TESTS
Select Standard Test from Engine Off test menu
Faults Found
Repair fault codes before continuing

PURPOSE

To determine if there are any electrical malfunctions that can be detected by the Electronic Control Module (ECM) during an “Output Circuit Check” self test.

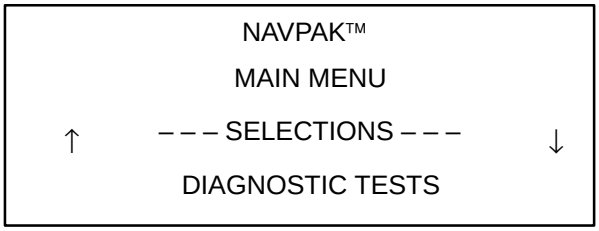
TEST PROCEDURE

NOTE: *Access “Diagnostic Codes” menu in est and clear all fault codes before performing engine off tests.*

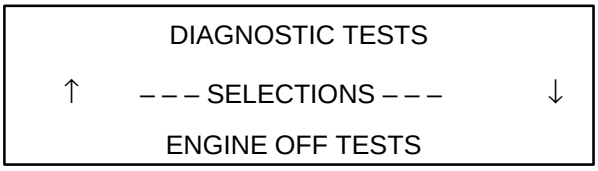
Access the **“ENGINE OFF TESTS”** in the **“DIAGNOSTIC TESTS”** section of the Electronic Service Tool (EST).

Press the **“FUNC**” key repeatedly, until the main menu appears on the screen.

Next select the **“DIAGNOSTIC TESTS”** menu by pressing the “↓” key, until **“DIAGNOSTIC TESTS”** is shown on the screen. Press **“ENTER”** to make this selection.



Press the “↓” key, until the **“ENGINE OFF TESTS”** is shown on the screen. At this point, press **“ENTER”**



After the **“ENTER”** key is pressed, the EST will command the ECM to perform an Output Circuit Check (OCC) self test. During this test, the ECM will test the electrical continuity of the output circuits.

EST Tool - Engine Off Tests (Continued)

When the test is complete, the screen will display the number of faults found in the self test. If there are any additional faults found, press **"ENTER"** and the faults will be displayed. If there is more than one fault that was found during the test, the "↑↓" symbol will be shown on the screen. Press the "↓" key to access any additional faults. The test is repeated by selecting, **"STANDARD TEST,"** under the **"ENGINE OFF TESTS"** menu, only new faults found will be displayed as "Faults Found."

NOTE: *If fault codes were not cleared before running engine off tests, all faults and associated codes recorded during the test will be stored as inactive codes by the EST. to read the codes, access the "INACTIVE CODE" menu.*

NOTE: *The program in the EST will only allow the engine off tests menu to be accessed once. To repeat engine off tests, select "standard test" to rerun the engine off tests.*

POSSIBLE CAUSES

- Defective electrical components or circuitry.
- Injection Pressure Regulator (IPR) output circuit check fault.

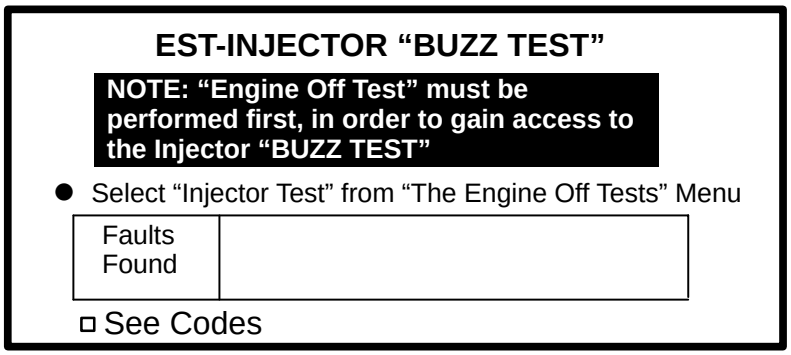
TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to fault code diagnosis and fault codes.

EST Tool - Injector Buzz Test


EST-INJECTOR "BUZZ TEST"
NOTE: "Engine Off Test" must be performed first, in order to gain access to the Injector "BUZZ TEST"
Select "Injector Test" from "The Engine Off Tests" Menu
Faults Found
See Codes

PURPOSE

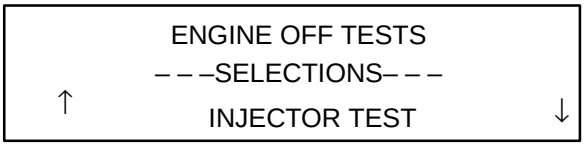
To determine if the injectors are electronically functioning correctly, by energizing each injector in a programmed sequence. The Electronic Control Module (ECM) will monitor this test and transmit fault codes if any injector(s) or electrical circuitry are not functioning properly.

TEST PROCEDURE

NOTE: *Access "diagnostic codes" menu in EST and clear all fault codes.*

NOTE: *Engine off test must be performed first in order to access the injector "buzz" test.*

After the **"Engine Off Standard Test"** has been completed, press the "↓" key to access the **"INJECTOR TEST."** If the tool is not on a menu screen, i.e. displaying of fault codes etc., press the **"FUNC"** key. This will access the **"ENGINE OFF TESTS"** menu. Press **"ENTER"** to begin the test.



During this test, the injector solenoids will produce an audible clicking sound when actuated. It is possible to detect a malfunctioning injector(s) by listening for the absence of the solenoid clicking sound.

NOTE: *If fault codes were cleared before the injector "buzz" test, fault codes displayed will be actual faults found during the test. If codes were not cleared before testing, access "inactive" fault codes from EST menu to retrieve faults found during this test.*

At the completion of the Injector Test, any faults that have been detected will be displayed. If there is more than one fault the "↑↓" symbol will be displayed. These additional faults can be accessed by pressing the "↓" key.

Record any faults found and refer to the Electronic Control System Diagnostics.

POSSIBLE CAUSES

- Bad wiring harness connection at injector solenoid.
- Open or shorted engine wiring harness to injector(s).
- Defective injector solenoid(s).
- Defective ECM injector driver circuit.

EST Tool - Injector Buzz Test (Continued)

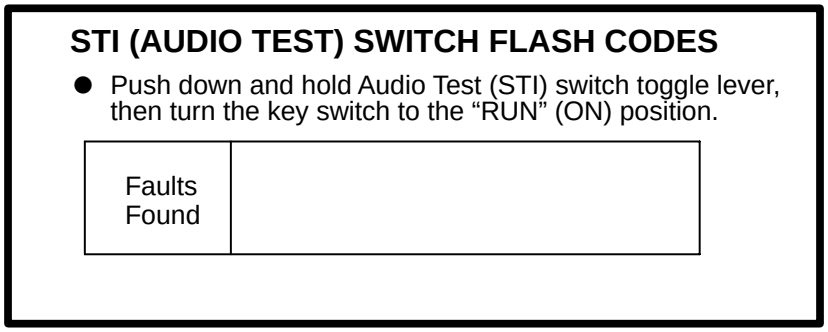
TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to fault code diagnosis.

STI (Audio Test) Switch - Flash Codes


STI (AUDIO TEST) SWITCH FLASH CODES
Push down and hold Audio Test (STI) switch toggle lever, then turn the key switch to the “RUN” (ON) position.
Faults Found

PURPOSE

To read faults detected by the Electronic Control Module (ECM), if the Electronic Service Tool (EST) is not available or the EST cannot receive “Self Test Input” data due to communications or component failures.

The Self Test Input (STI) switch is also the Audio Test/Panel Lights toggle switch located on the instrument panel. Pushing and holding the Audio Test (STI) switch toggle lever down while turning the ignition switch to the RUN (ON) position, will signal the ECM to start the Self Test Input diagnostics to check output circuits. If any faults are detected, the ECM will flash the “CHECK ENGINE” lamp to indicate which faults have been detected.

NOTE: *Self test input diagnostics will not flash some FAULT CODES.*

TEST PROCEDURE

Push and hold the Audio Test switch toggle lever down. Turn the ignition switch to the RUN (ON) position. **Do Not Start The Engine.** The ECM will begin to perform the self test to check the output circuits.

When the test is completed, the ECM will flash the **“COOLANT TEMPERATURE”** lamp and **“CHECK ENGINE”** lamp to signal the fault codes.

NOTE: *Fault codes can be accessed at anytime by pushing and holding the Audio Test (STI) switch toggle lever down while turning the ignition switch to the RUN (ON) position*

To read the fault codes it will be necessary to count the number of times the **“CHECK ENGINE”** lamp flashes. The following sequence of events occur each time the Audio Test switch lever is pushed to obtain the fault codes:

1. The **“COOLANT TEMPERATURE”** lamp will flash one time to indicate the beginning of **Active** fault codes.
2. The **“CHECK ENGINE”** lamp will flash repeatedly signaling the active fault codes.

NOTE: *All fault codes are three digits and code 111 indicates “no faults” have been detected.*

3. Count the number of flashes in sequence. At the end of each digit of the code there will be a short pause. Three flashes and a pause would indicate the number 3. Therefore, two flashes, a pause, three flashes a pause, and two flashes a pause would indicate the code 232. If there is more than one fault code, the **"COOLANT TEMPERATURE"** lamp will flash once indicating the beginning of another active fault code.

After all the active codes have been flashed, the **"COOLANT TEMPERATURE"** lamp will flash twice to indicate the beginning of **INACTIVE** codes. Count the number of flashes from the **"CHECK ENGINE"** lamp. If there is more than one inactive code, the **"COOLANT TEMPERATURE"** lamp will flash once in-between each fault code.

After all codes have been sent, the **"COOLANT TEMPERATURE"** lamp will flash three times indicating "END OF MESSAGE".

To repeat transmission of fault codes, push the Audio Test switch lever down (with the key switch still in the RUN position). This action will signal the ECM to resend all stored fault codes.

If fault codes are set, refer to fault code diagnosis.

POSSIBLE CAUSES

- Electronic component or circuitry failures.

TOOLS REQUIRED

None.

EST Tool - Data List

EST TOOL-DATA LIST

- Select and enter the following data as the first three lines in a custom data list
- Monitor the data while cranking the engine for 20 seconds minimum

Data	Spec.	Actual
Bat. voltage	7 volts min.	
Eng. RPM	130 RPM min.	
ICP pressure	800 PSI min.	

☐ If voltage is low, proceed to SECTION 5C.

☐ If no RPM is noted, recheck fault codes and proceed to test “Engine Cranking RPM.”

☐ If ICP pressure is low, refer to system leak tests.

PURPOSE

To determine if the components needed for starting are operating within specifications.

TEST PROCEDURE

IMPORTANT: Test must be performed with Fully Charged Batteries.

To measure engine cranking speed, battery voltage, and Injection Control Pressure (ICP), it may be possible to read the data on the Electronic Service Tool (EST), “DATA LIST,” while the engine is cranking. If the voltage drops below 7 volts while cranking, the EST tool will “RESET” back to start-up. If this happens, the tool can be used to perform this test by setting a “Custom Data List.” **Refer to Test 9**, “Testing Voltage, RPM and ICP individually” using the Fluke 88 DVOM as as alternative.

NOTE: *Turn all accessories and the ignition OFF, before connecting EST tool to ATA (American Trucking Association) diagnostic connector.*

Connect the EST tool to the engine or instrument panel diagnostic connector. The screen of the reader should light up as soon as the tool is plugged in.

Turn the ignition switch to the RUN (ON) position. **Do not start the engine.** This will allow the EST to receive data from the electronic control components.

If no data is received press **“ENTER”** to retry. The information received will be data indicating the current status of the engine.

NAVPAK™ DATA LIST

RATED HP	175
RATED RPM	2300
ACTIVE CODES	NO
INACTIVE CODES	NO

EST Tool - Data List (Cont.)

Press the "↓" key until "BATT VOLTS" appears on the screen. Continue to press the "↓" key until the black dot is on "BATT VOLTS." Press **"FUNC"** to return to Standard Data List**.**

BATT VOLTS	12.5
ENG. OIL TEMP	75 F
AMBIENT AIR	75 F
COOLANT TEMP	75 F

Now press the "↓" key until the black dot is on "ENGINE RPM."

BATT VOLTS	12.5
ENGINE RPM	0

Continue to press the "↓" key until "INJ CNTL PSI" is highlighted with a black dot.

BATT VOLTS	12.5
ENGINE RPM	0
INJ CNTL PSI	0

The EST is now ready to read the data needed. Crank the engine while observing the data on the screen. If the EST recycles to the entry screen or shuts down, it will be necessary to measure the values separately. If this is required, continue on ECM voltage check.

The battery voltage must be 7 or more volts. If the voltage to the Electronic Control Module (ECM) drops below 7 volts, the ECM will not remain powered up. If the ECM is not receiving power via the ECM relay, the engine cannot be started.

Engine cranking RPM must be sufficient to generate the required Injection Control Pressure to operate the fuel injectors and to create enough compression heat to ignite the fuel.

A "0" RPM indication on the Electronic Service Tool (EST) during engine cranking, indicates the ECM may not be receiving a signal from the Camshaft Position (CMP) sensor. Refer to CMP sensor diagnostics.

If the CMP sensor is inoperative, it must be repaired before continuing. The ECM will not allow the Injector Pressure Regulator (IPR) valve to fully activate without a CMP signal.

If the EST indicates little or no injection control pressure check oil level in reservoir. Remove the inspection plug in top of the oil reservoir and check the oil level. Normal oil level is within 1/2 inch from top of reservoir. Normal oil level in the reservoir will allow the system to prime faster, facilitating starting.

If the oil level in the reservoir becomes low while cranking the engine, this is an indication that oil is not being pumped to the reservoir.

IMPORTANT: Test must be performed with <u>Fully</u> <u>Charged</u> <u>Batteries</u>.

EST Tool - Data List (Cont.)

POSSIBLE CAUSES

- Low battery voltage. Due to “faulty” batteries, high resistance at battery cable connections or in the wiring to the ECM.
- Defective ECM power relay.
- Blown 15A in-line fuse which supplies battery power (voltage) to ECM.
- Low cranking RPM. May be caused by electrical system malfunctions, incorrect oil or extended oil change intervals in cold ambient temperatures.
- No engine RPM indication on EST while cranking the engine. CMP sensor or faulty circuitry to the ECM may cause this condition. Recheck for fault codes after cranking engine.
- Low ICP Pressure. May indicate a leak in the high pressure oil system or a defective CMP sensor.
- A defective high pressure oil pump or pump drive will prevent proper injection control pressure. A defective Injection Pressure Regulator (IPR), or electronic controls for the regulator will cause low injection control pressure.

TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

SUPPLEMENTAL DIAGNOSTICS

- Low voltage at ECM. Refer to Electronic Control Module Power Supply (ECM PWR).
- No Engine RPM indication during engine cranking. Refer to CMP sensor diagnostics.
- No Injection Control Pressure. Refer to Injection Control Pressure (ICP) sensor, IPR valve diagnostics.
- No or low injection control pressure and no electronic faults. Refer to High Pressure Leakage tests.

ECM Voltage

ECM VOLTAGE

- Check while cranking engine
- Measure with DVOM at three locations with breakout box connected to black connector on ECM

Pins: (21+ & 1–) (22+ & 2–) (24+ & 23–)

Instrument	Spec.	Actual
DVOM & Breakout Box	7 volts minimum @ all 3 locations	

□ If voltage is low, refer to ECM diagnostics

PURPOSE

To determine if there is sufficient voltage and current to operate the Electronic Control Module (ECM). The ECM requires 7 volts minimum to operate and drive the injectors. This is an alternate method to be used if the Electronic Service Tool (EST) is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

TEST PROCEDURE

IMPORTANT: Tests must be performed with Fully Charged Batteries.

Voltage measurement at battery:

1. Connect a DVOM (Digital Volt Ohm Meter) across the battery terminals.
2. Turn all accessories off and turn the ignition switch to the “ON” position.
3. Wait for the glow plug system to cycle, then crank the engine.

Record the lowest voltage obtained during engine cranking. If the voltage is below 7 volts, the ECM power relays may be resetting due to the lack of voltage and current from the batteries or a problem exists in the starting system.

If voltage is within specification, perform **Voltage Measurement At The ECM with Breakout Box.**

Voltage measurement at ECM with Breakout Box:

1. Remove the 60 way (black) connector from the ECM harness.
2. Install breakout box adapter to the female connection on ECM. Reconnect black connector to the breakout box adapter connector.
3. Connect leads of the voltmeter to each of the three separate test points [(21+ & 1–), (22+ & 2–), (24+ & 23–)] on the breakout box.
4. Record the lowest voltage observed at each of the test points while cranking engine.
5. If voltage is lower than 7 volts, repair the ECM power feed circuit. Refer to Electronic Control Module (ECM PWR) Power Circuit diagnostics.

ECM Voltage (Cont.)

POSSIBLE CAUSES

- Low battery voltage. Due to “faulty” batteries, high resistance at battery cable connections or defective starter.
- Low or no battery voltage to the ECM. May be due to high resistance or an open circuit in the power feed circuit to the ECM or it’s power relay. The ECM power circuit fuse, may be open or the ECM power relay may be defective.

TOOLS REQUIRED

DVOM and Breakout Box.

SUPPLEMENTAL DIAGNOSTICS

Refer to Electronic Control Module Power Supply (ECM PWR).

Engine Cranking RPM

ENGINE CRANKING RPM

- Minimum 130 RPM engine cranking speed for 20 seconds.
- Measure with breakout box connected to Engine Harness on ECM @ pins 51+ & 19–

Instrument	Spec.	Actual
Fluke 88 51+ & 19–	130 RPM minimum	

- ☐ If no RPM is noted, recheck fault codes

PURPOSE

To determine if engine cranking speed is high enough to start the engine and confirm that the (CMP) camshaft position sensor is functioning properly. This is an alternate method to be used if the Electronic Service Tool (EST) is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

TEST PROCEDURE

IMPORTANT: Test must be performed with Fully Charged Batteries.

Engine cranking RPM must be sufficient to generate the required Injection Control Pressure to operate the fuel injectors and to create enough compression heat to ignite the fuel.

Checking cranking RPM with breakout box:

1. Remove the 60 way connector from the Electronic Control Module (ECM). Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter.
2. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.

NOTE: *Torque the connector to ECM to 35 lb-in (4 Nm).*

3. Connect the (+ lead) of the Fluke 88 to terminal 51 and the (- lead) to terminal 19. Select the DC voltage scale and press the “RPM” button.
4. Crank the engine while observing the DVOM. A minimum of 130 RPM is necessary to start the engine.
5. Record cranking engine RPM on diagnostic form.

A “0” frequency indication on the Fluke 88 during engine cranking, may indicate the ECM is not receiving a signal from the Camshaft Position (CMP) sensor. Refer to CMP sensor diagnostics.

If the CMP sensor is inoperative, it must be repaired before continuing. The ECM will not allow the Injector Pressure Regulator valve to fully activate without a CMP signal.

NOTE: *If no engine RPM is measured with the Fluke 88, check for additional fault codes. Refer to tests 5 & 7 and electronic control system diagnostics section, for Camshaft Position (CMP) sensor diagnostics.*

Engine Cranking RPM (Continued)

POSSIBLE CAUSES

- Low cranking RPM. Starting system electrical malfunctions. Incorrect oil type or extended oil change intervals in cold ambient temperature conditions.
- No engine RPM. Poor connection at CMP sensor wiring harness connector, wiring harness to sensor open or shorted or CMP sensor is defective.

TOOLS REQUIRED

FLuke 88 DVOM and Breakout Box (ZTSE-4445).

SUPPLEMENTAL DIAGNOSTICS

Refer to CMP sensor diagnostics, in Electronic Control System Diagnostics.

Injection Control Pressure

INJECTION CONTROL PRESSURE

- Check during engine cranking. (min. 130 RPM) for 20 sec.
- Measure w/ breakout box connected to Engine Harness on ECM @ pins 16+ & 19– or breakout “Tee” signal (green) & ground (black).

Instrument	Spec.	Actual
DVOM 16+ & 19–	1 to 4 volts	

☐ If less than 1 volt, recheck oil level in reservoir.
If ICP pressure is low, recheck oil in reservoir.
If pressure is still low, refer to system leakage tests.

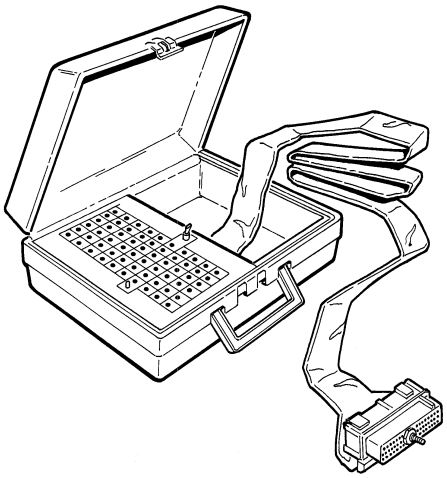
PURPOSE

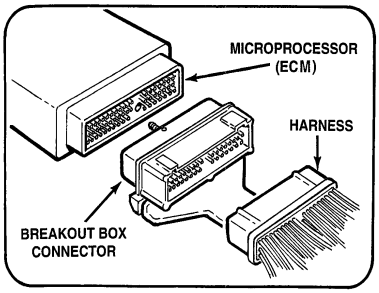
To determine if the injection control pressure system is supplying sufficient oil pressure to start and operate the engine. This is an alternate method to be used if the Electronic Service Tool (EST) is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

TEST PROCEDURE

Measuring Injection Control Pressure using breakout box:

1. Remove the 60 way connector from the ECM. Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter.



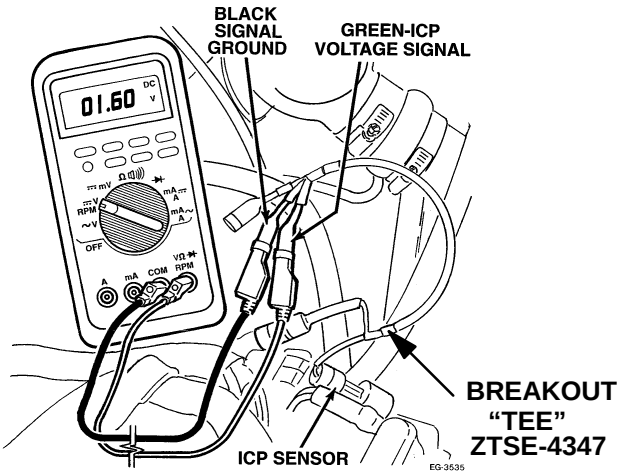


2. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.

NOTE: *Torque connector to ECM to 35 lb-in.*

3. Connect the positive lead of the DVOM to terminal 16 and the negative lead to terminal 19.
4. Crank the engine while observing the DVOM and record the injection control pressure voltage signal on diagnostic form. **If Injection Control Pressure (ICP) is low, refer to High Pressure Leakage Tests.**

Injection Control Pressure (Continued)



ALTERNATE METHOD OF MEASURING INJECTION CONTROL PRESSURE USING (BREAKOUT "TEE")

1. Remove engine harness connector at ICP sensor.
2. Connect the breakout "TEE" (ZTSE-4347) to the removed engine harness connector and the ICP sensor.
3. Connect DVOM leads (+Green, -Black) to the breakout "TEE" as shown.
4. Crank engine and observe DVOM voltage reading. Record reading on diagnostic form. If voltage is low, recheck oil level in reservoir to confirm the reservoir contains a sufficient supply of oil to enable the injection control system to function properly. If oil level is OK, proceed to High Pressure Leakage tests.

POSSIBLE CAUSES

Low injection pressure (voltage) indicates the injectors are not receiving sufficient oil pressure to properly operate the fuel injectors. This may be caused by:

- No oil in engine.
- Oil reservoir oil level low.
- Defective high pressure pump.
- Injector O-ring leak.
- Injector body leak.
- IPR valve stuck open.
- Pump drive gear loose or damaged.

TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661) or DVOM and ICP sensor breakout "Tee" (ZTSE-4347).

SUPPLEMENTAL DIAGNOSTICS

Refer to Injection Pressure Regulator (IPR) diagnostics, in Electronic Control System Diagnostics.

High Pressure Leakage Tests

ISOLATE RIGHT CYLINDER HEAD

Remove high pressure hose from the right cylinder head. Use an Aero Equip size 6 flare plug and install into the high pressure hose to block it off. Crank the engine and monitor the Injection Control Pressure (ICP) signal.

⚠ CAUTION

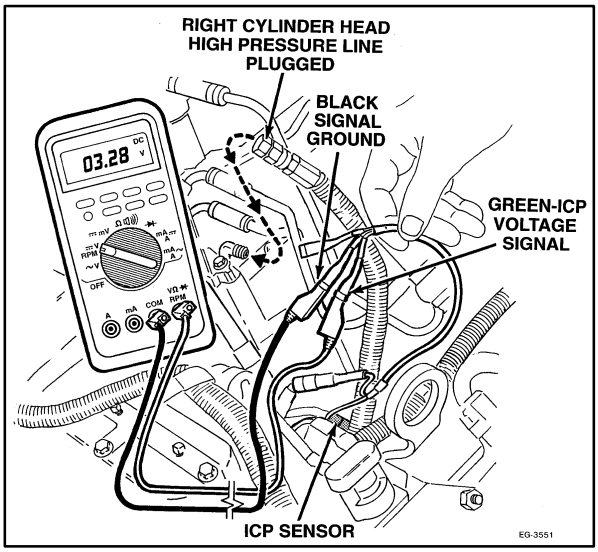
The Engine May Start!

If the engine fails to start, refer to procedure on Isolating Left Cylinder Head. If the engine starts or the ICP pressure is now within specifications, the injection control pressure leak has been isolated to the right cylinder head.

1. Remove flare plug from the high pressure supply hose and reconnect hose to right cylinder head.
2. Remove valve cover on right cylinder head.
3. Crank the engine and inspect the injector body and bore area for leakage. If no leakage is detected, perform ICP Leakage Test page.

⚠ CAUTION

Oil is under high pressure.



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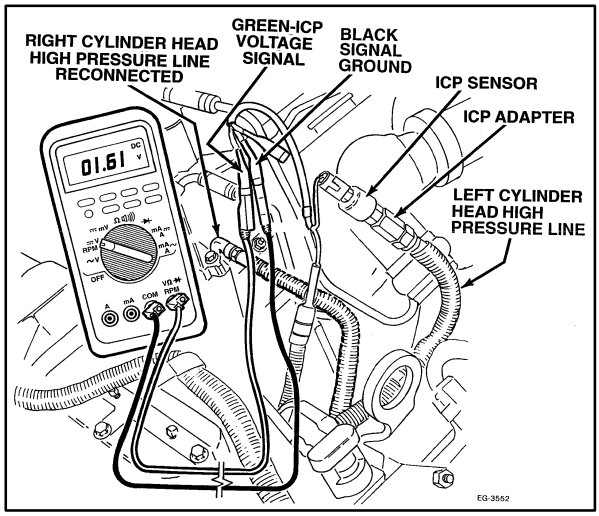
ISOLATE LEFT CYLINDER HEAD

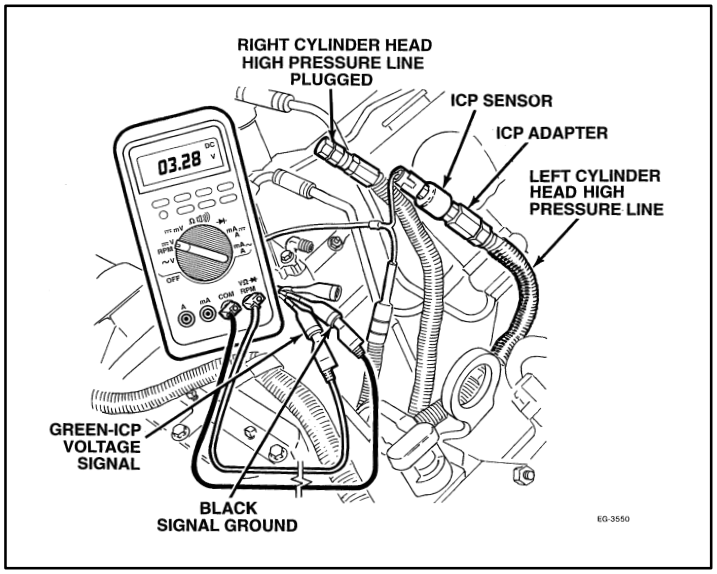
Remove the plug (from previous step) in the right cylinder head high pressure hose and reconnect hose to cylinder head. Remove the high pressure hose from the left cylinder head. Remove the ICP sensor and assemble it to the ICP adapter. Install the ICP sensor/adapter onto the high pressure hose. Crank the engine and monitor the ICP signal.

NOTE: *If the ICP pressure is not within specification, proceed to IPR and High Pressure Pump Test page.*

High Pressure Leakage Tests (Continued)

If the engine starts, or the ICP pressure is now within specifications, the injection control pressure leak has been isolated to the left cylinder head. Reattach the left side high pressure hose. Remove left valve cover and crank the engine. Inspect the injector body and bore area for oil leakage. If no leakage is detected, perform ICP Leakage Test page.

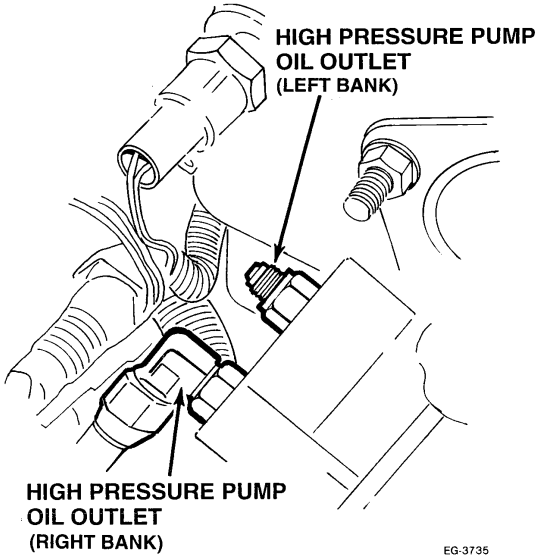




IPR AND HIGH PRESSURE PUMP TEST

If injection control pressure is still low after isolating both cylinder heads, leave the ICP sensor adapter in the left hose and reinstall the flare plug to block the right high pressure hose and crank the engine. This has effectively deadheaded the high pressure pump. If pressure is still not developed, inspect the IPR (Injection Pressure Regulator) valve for debris and/or replace with a known good valve and retest. If pressure is still low, check the high pressure pump and drive gear. The gear may be loose or the pump may be defective.

ICP Leakage Test



1. Reconnect all high pressure oil lines disconnected in the process of isolating the cylinder head which is causing a loss of ICP pressure.
2. Remove the high pressure supply line of the suspect leaking cylinder head at the high pressure pump.
3. Connect a regulated air supply to the high pressure supply oil line removed in the previous step.
4. Apply 100 psi (689 kPa) of pressure from the regulated air source and inspect for leakage around the injectors.
5. With the fuel lines removed from the fuel regulator block, inspect for oil leakage out of each of the disconnected fuel lines. If oil is seeping out of the disconnected fuel lines remove all injectors in the cylinder head being tested and inspect injectors for worn O-rings or obvious damage.

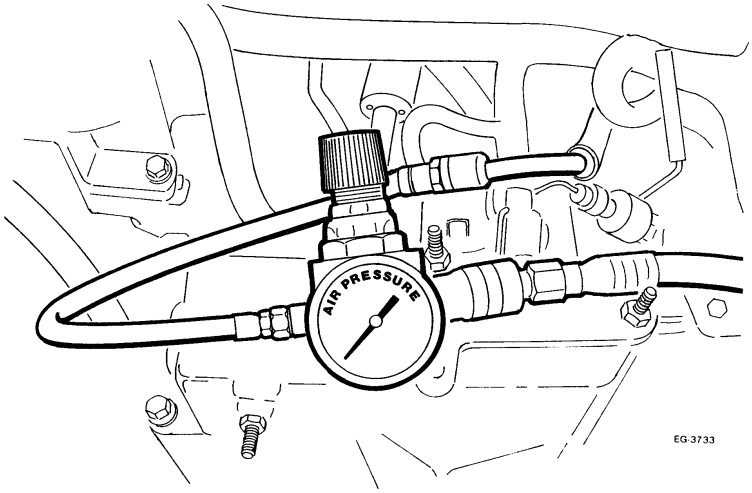
If leakage is observed at an injector, remove and inspect injector for obvious damage or worn O-rings.

If no leakage is present, perform Injector “Buzz” test with air pressure still applied. Observe oil discharge from each of the injectors. Oil discharge should be equal from all injectors. If excess oil is discharged from an injector(s), the injector(s) may be defective.

6. If it is difficult to determine which injector(s) are leaking remove air supply and regulator from the high pressure oil supply hose and:
   a. Connect an **automotive cylinder leak tester** to the high pressure supply hose and apply air pressure via the cylinder leak tester.
   b. Conduct an Injector “Buzz” test and observe the percent cylinder leakage while each injector is activated. Remove and inspect injectors which exhibit a greater amount of leakage compared to the others.
   c. If none of the injectors indicate an excessive amount of leakage, remove all injectors. Inspect all O-rings for wear and damage. All O-rings should be replaced.

If oil was entering the fuel system, drain fuel tanks and dispose of the contaminated fuel properly.

ICP Leakage Test (Continued)



POSSIBLE CAUSES

- No oil in engine.
- Oil reservoir leak down possibly through high pressure pump check valve.
- Defective high pressure pump
- Injector O-ring leak.
- Injector body leak.
- IPR valve stuck open.
- Pump drive gear loose or damaged.

TOOLS REQUIRED

DVOM, ICP sensor breakout “Tee” (ZTSE-4347), ICP adapter and an Aero Equip® size 6 flare plug.

SUPPLEMENTAL DIAGNOSTICS

Camshaft Position (CMP) sensor diagnostics, in Electronic Control System Diagnostics.

Fuel Pump Pressure

FUEL PUMP PRESSURE

- Measure at regulator block
- Minimum 130 RPM cranking speed for 20 seconds

Instrument	Spec.	Actual
0 - 160 PSI (0 - 1100 kPa) Gauge	30 PSI (206 kPa) minimum	

☐ **If pressure is low, replace fuel filter and retest.**

☐ **If pressure is still low, see Performance diagnostics.**

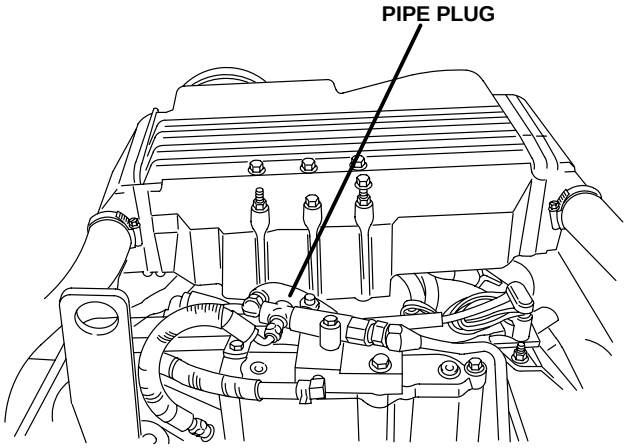
PURPOSE

To determine if fuel pressure is sufficient to start and operate the engine.

NOTE: *If the fuel filter is equipped with a water-in-fuel probe, check to determine if the water-in-fuel lamp has been illuminated during operation.*

TEST PROCEDURE

1. Remove 1/8 inch pipe plug located on the fuel regulator block. Install 1/8 inch pipe fitting in place of the pipe plug.



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2. Connect a line from the fitting to the 0-160 psi (0 - 1100 kPa) gauge of the Model D-200 Pressure Test Kit.
3. Measure fuel pressure by cranking engine for 20 seconds and observing maximum pressure. Record pressure on diagnostic form and compare to specifications. **If fuel pressure is low, change the fuel filter and retest.**

NOTE: *It may take a number of crank cycles to purge the air out of the fuel system.*

Fuel Pump Pressure (Continued)

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Change filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Gauge Bar PS94-831-3, or Model D-200 Pressure Test Kit (ZTSE-2239) [0 to 160 psi (0 - 1100 kPa) fuel pressure gauge], appropriate line with 1/8 inch NPT fitting.

Glow Plug System

GLOW PLUG SYSTEM
Relay Operation

- Install a voltmeter to the glow plug feed terminal (terminal w/2 wires)
- Turn key to “RUN” (ON) position. Measure “ON” time.
- Verify sufficient glow plug “ON” time using voltmeter to verify glow plugs are receiving the required voltage within the specified time.

(Dependent upon coolant temperature, battery voltage and altitude)

	Spec.	Actual
Relay On Time	10 - 120 seconds	
Voltage	9 - 12 Volts	

(Relay may not cycle on, if engine is at operating temperature)

GLOW PLUG OPERATION

- Remove all glow plug/injector connectors.
- Measure glow plug resistance to Bat. Grd.
- Measure GP harness resistance to relay.

Glow Plug Number	Plug to Ground .1 to 6 Ohms	Harness to Relay < 1 Ohm
#1		
#3		
#5		
#7		
#2		
#4		
#6		
#8		

PURPOSE

To determine if the glow plug system is operating sufficiently to start a cold engine.

TEST PROCEDURE:

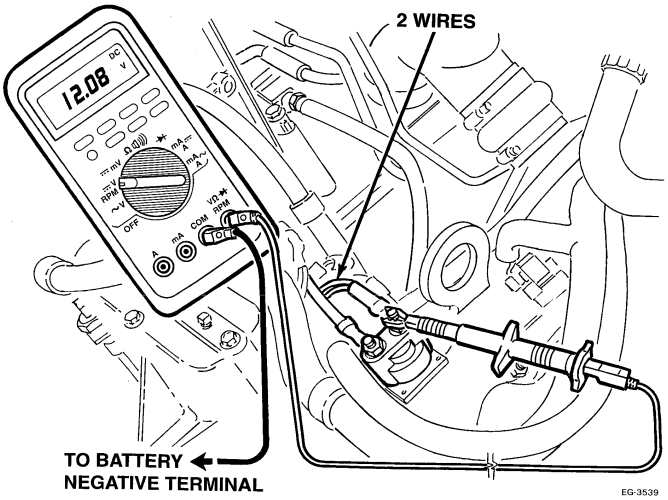
Glow Plug “ON” Time:

Connect a DVOM to the glow plug feed terminal (terminal with 2 wires) on the glow plug relay. The DVOM will verify that the glow plugs are receiving the required voltage (9-12v) for the specified amount of time. Turn the key switch to the RUN (ON) position.

DO NOT ATTEMPT TO START ENGINE. Note the time in seconds from when the key switch is turned to the RUN position until the glow plug relay de-energizes (0 volts indication on the DVOM).

Glow Plug System (Continued)

NOTE: *Glow plug "ON" time will be affected by engine coolant temperature, battery condition and altitude.*



Typical Glow Plug Relay Shown

If no voltage is present, check for voltage at the other large terminal of the glow plug relay. If no voltage present, refer to glow plug system diagnostics in Electronic Control System Diagnostics.

POSSIBLE CAUSES

Insufficient glow plug on time will not allow enough heat to accumulate in the combustion chamber to easily facilitate starting. If the glow plug system "ON" time does not meet specifications the problem may be:

- Faulty wire harness connection.
- Poor ground connection.
- Defective glow plug relay.
- ECM in default
- ECM defective.

TEST PROCEDURE

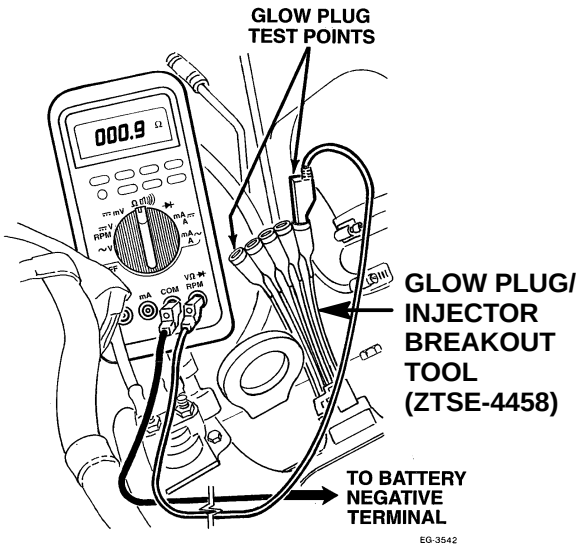
Glow Plug Resistance To Battery Ground (-) Terminal 4.

Disconnect the (2) glow plug/injector harness connectors from the valve cover gasket (UVC) harness.

NOTE: *Incorrect measurements will result, if all glow plug and injector harness connectors are not disconnected.*

Connect pigtail tool to each valve cover harness connector to measure glow plug resistance to (ground) battery negative terminal. Record resistance measurements on diagnostic form. A resistance measurement of .1 to 6 ohms indicates a good glow plug.

Glow Plug System (Continued)



Typical Injector Breakout Tool and Usage Shown

If the glow plug resistance to ground is high the most likely causes are:

- Open UVC (under valve cover) harness.
- Open glow plug.

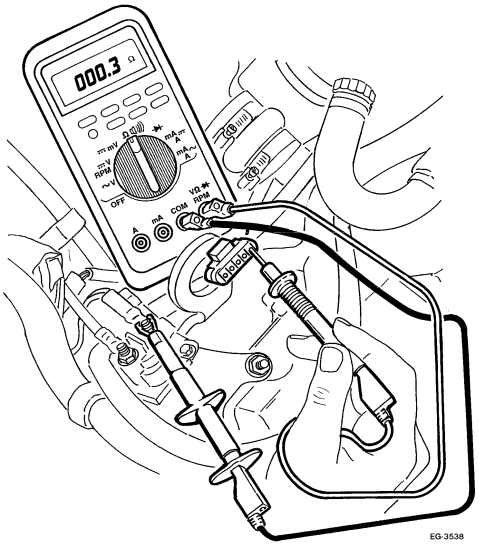
Glow Plug Harness Resistance To Relay

Measure resistance from the engine harness connector to the glow plug feed terminal on the glow plug relay.

NOTE: *Incorrect measurements will result, if all glow plug/injector harness connectors are not disconnected.*

TOOLS REQUIRED

DVOM, Glow Plug/Injector Breakout Tool (ZTSE-4458) and Stop Watch or equivalent.



Typical UVC Harness Connector Testing Shown

Performance Diagnostics

Check Engine Oil Level

CHECK ENGINE OIL LEVEL

- Check for contaminants (fuel, coolant)
- Correct grade/Viscosity

Method	Check
Visual	

☐ If idle quality is poor after extended running, refer to “Injection Control Pressure Test.“

PURPOSE

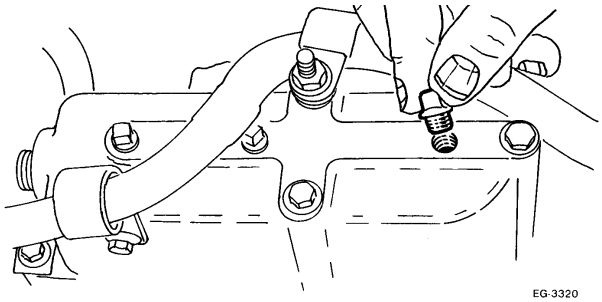
To determine if the crankcase and oil reservoir contain engine oil of sufficient quantity and quality to enable the injection control pressure system to function properly.

TEST PROCEDURE

1. Check oil level with oil level gauge. If there is no oil or very little oil in the crankcase the fuel injectors will not operate.

If the oil level on the gauge is over full, it is possible the engine was incorrectly serviced or fuel is diluting the oil and filling the crankcase. If a substantial amount of fuel is in the oil, it will have a fuel odor.

2. Inspect oil for color. A milky white oil indicates possible coolant contamination and will have an ethylene glycol odor.
3. Check service records for correct oil type and viscosity, for the temperature (environment) that engine is operating in. Single weight or 15W 40 oil is not recommended for cold ambient temperatures. Oil that has had extended drain intervals will have increased viscosity (become thicker) and will make engine cranking more difficult and starting less reliable at temperatures below freezing. Refer to lube oil chart in the Operation, Maintenance and Warranty Manual or Service Manual Number 27, SECTION 1B, for the correct oil selection for temperature conditions.
4. Check oil level in reservoir.



Removing Inspection Plug

Check Engine Oil Level (Continued)

POSSIBLE CAUSES

- Oil level low - Oil leak, oil consumption, incorrect servicing.
- Oil level high - Incorrect servicing, fuel dilution from lift pump or defective injector O-rings.
- Oil contamination with coolant, oil cooler seawater contamination, head gasket, porosity.
- Low reservoir level - Engine built dry (not pressured lubed).

TOOLS REQUIRED

1/4” drive ratchet or breaker bar to remove inspection plug.

Sufficient Fuel / Pressure

SUFFICIENT FUEL / PRESSURE

- Drain sample from tank(s)
- Inspect fuel for contamination
- Measure fuel pressure at regulator block
- Measure pressure at high idle

Instrument	Spec.	Actual
0-160 psi (0 - 1100 kPa) Gauge	65 psi (448 kPa) min. @ high idle	

☐ If pressure is low, replace fuel filter and retest.

☐ If pressure is still low, proceed with Test

PURPOSE

To determine if the fuel system is getting sufficient clean fuel at proper pressure to start and operate the engine.

TEST PROCEDURE - SUFFICIENT / CLEAN FUEL

1. Obtain fuel sample from fuel tank.

NOTE: *Fuel must be of proper grade, clean and undiluted.*

2. Inspect fuel in container. It must be clean and free of air, contaminants, water, icing or clouding. The fuel should be straw colored. Fuel dyed red or blue indicates an off-highway fuel.
3. Check fuel odor for the presence of other fuels such as gasoline or kerosene.

If engine oil is present in the fuel, it may indicate an injector O-ring leak and subsequent loss of injection control pressure. Refer to ICP Pressure, and ICP Leakage Tests for determining the cause of oil present in the fuel. After the cause has been determined and the repair made, drain the fuel tank(s) and dispose of the contaminated fuel properly.

Sufficient Fuel / Pressure (Continued)

TEST PROCEDURE - FUEL PRESSURE

1. Remove 1/8” pipe plug located on the fuel regulator block. Install 1/8 inch (3 mm) pipe fitting in place of the pipe plug.
2. Connect a line from the fitting to the 0-160 psi gauge on Gauge Bar (PS94-831-3). Start engine and run at low idle to check for fuel leaks in line to the pressure gauge.

NOTE: *Bleed air from fuel line connected to pressure gauge to insure an accurate reading.*

3. Measure fuel pressure at high idle. Record pressure on diagnostic form and compare to specifications. **If fuel pressure is not within specifications replace fuel filter, clean fuel strainer and retest.**

NOTE: *It may take a number of crank cycles to purge the air out of the fuel system after replacing the fuel filter.*

If pressure is low after replacing the filter and cleaning the strainer, perform Transfer Pump Restriction Test 2b.

LOW OR NO FUEL POSSIBLE CAUSES

- No fuel in tank.
- If equipped with a in-line fuel valve, it could be shut off.
- Fuel supply line from tank(s) could be broken or crimped.
- Fuel could be waxed or jelled (most likely in cold weather with #2 fuel), the pickup tube in tank could be clogged or cracked. If there is excessive water in the tank, it could freeze preventing the fuel from being drawn to the engine.
- If the vessel is equipped with supplemental filters or water separators, check for plugged filters or leakage that could allow the engine to draw air.
- Cloudy fuel indicates that the fuel may not be a suitable grade for cold temperatures. Excessive water or contaminants in fuel may indicate that the tank and fuel system may need to be flushed and cleaned.

TOOLS REQUIRED

Clear container [approximately 1 quart (1 L)]. Gauge Bar (PS94-831-3), or Model D-200 Pressure Test Kit (ZTSE–2239) [0 to 160 psi (0-1100 kPa) fuel pressure gauge], or fuel pressure gauge and appropriate line with 1/8 in. NPT fitting.

Transfer Pump Restriction Test

TRANSFER PUMP RESTRICTION

- Measure at fuel pump inlet
- Measure at High idle

Instrument	Spec.	Actual
0-30” Hg (0-762 mm Hg) Vacuum Gauge	< 6 in. Hg (152 mm Hg)	

☐ If restriction is high, check for blockage between pump and fuel tank.

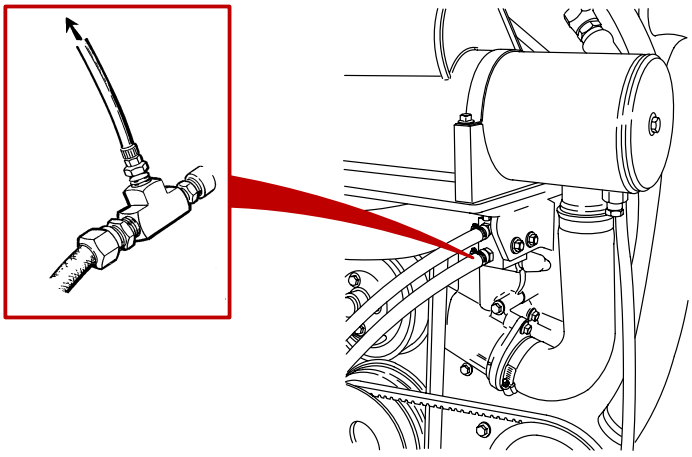
☐ If restriction is within spec., check for sticking regulator valve or debris.

PURPOSE

To determine if excessive restriction to fuel flow exists from the engine fuel inlet line to the fuel tank(s).

TEST PROCEDURE

1. Connect a Tee between the fuel inlet line from tank and fuel supply line fitting. Connect a line from the tee to the 0-30 in. Hg (0 - 762 mm Hg) vacuum gauge of the D-200 Pressure Test Kit (ZTSE-2239).



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2. Measure fuel inlet restriction at high idle.
3. If restriction exceeds 6 in. Hg (152 mm Hg), locate the restriction on the suction side of the fuel system and correct.

NOTE: *If fuel inlet restriction is within specifications, refer to fuel regulator valve removal and inspection.*

Transfer Pump Restriction Test (Continued)

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Replace filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Gauge Bar (PS94–831–3) or Model D-200 Pressure Test Kit (ZTSE–2239), [0 to 30 in. Hg. (0 to 762 mm Hg) vacuum gauge], Tee fitting, and appropriate fuel lines.

EST Tool Fault Codes

EST TOOL-FAULT CODES

- Install Electronic Service Tool
- Select Diagnostic Codes

Active	
Inactive	

☐ See Codes

PURPOSE

To determine if the Electronic Control Module (ECM) has detected any fault conditions that would cause a hard or no start condition.

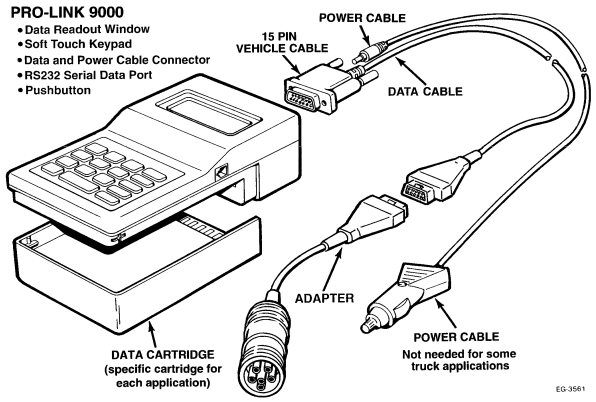
TEST PROCEDURE

NOTE: *Turn all accessories and the key switch OFF, before connecting EST tool to the ATA (American Trucking Association) diagnostic connector.*

Connect the Electronic Service Tool (EST) to the ATA diagnostic connector. There is a connector located on the engine and at the instrument panel.

The screen of the reader should light up as soon as the tool is plugged in.

NOTE: *The ATA connector supplies power to operate the EST. The EST will automatically power up as soon as it is plugged into the ATA connector. The power cord is not required and is for use only when reading non-volatile memory.*



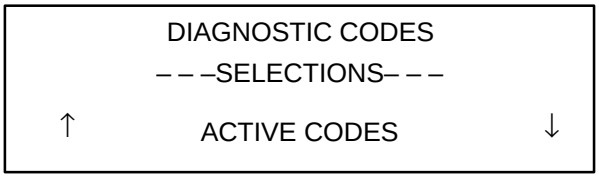
Turn the key switch to the RUN (ON) position, but **do not start** the engine. This will allow the EST to receive data from the electronic control components. If no data is received, press **"ENTER"** for "NAVPAK™." The information received will be data showing the current status of the engine.

To access the fault codes press the **"FUNC"** key to switch to the main menu.

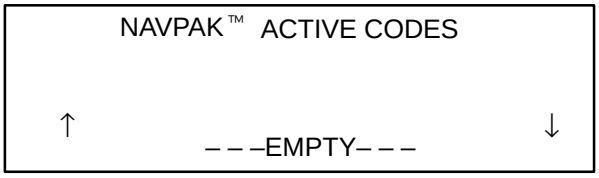
NAVPAK™ MENU
– – –SELECTIONS– – –
↑ DIAGNOSTIC CODES ↓

EST Tool Fault Codes (Continued)

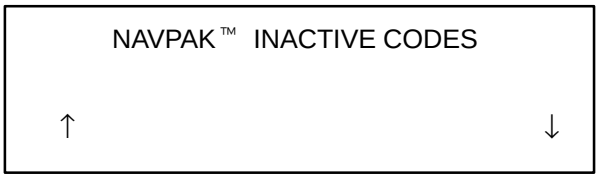
From the main menu press the "↓" key to select "**DIAGNOSTIC CODES.**" The selection will have the "↑↓" symbol on the screen. This means there are other selections available. By pressing the "↓" key the other selections will display on the screen. Press "↓" until **"DIAGNOSTIC CODES"** appears on the screen. Next press **"ENTER."** You are now in the diagnostic codes selection of the tool. From this point, diagnostic codes can be accessed.



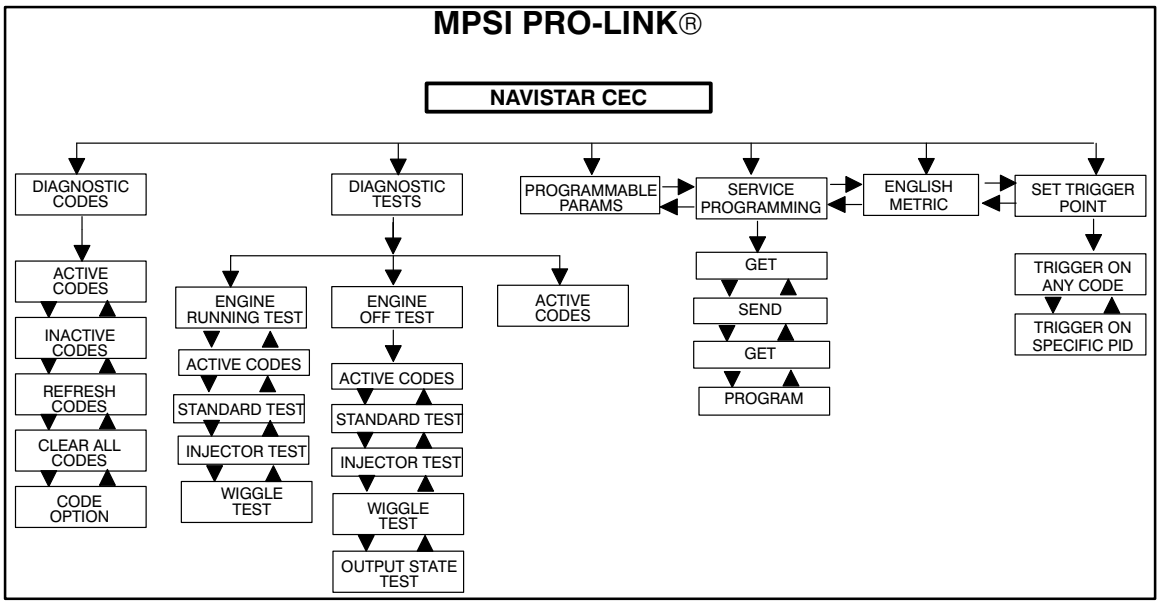
The first option that will appear is **"ACTIVE CODES."** By selecting this option, the fault codes that have occurred during this key "ON" cycle will be displayed. Press **"ENTER."** If there are any "Active Codes," the first one will appear on the screen along with a description of the code. Press "↓" key to access additional codes. If there are not any codes "Active," **"EMPTY"** will appear on the screen .



To access "Inactive Codes" press the **"FUNC"** key. This will access the last prior selection. Then press the "↓" key to select **"INACTIVE CODES"** Press the **"ENTER"** key.



The EST arrangement of menus is as follows:



EST Tool Fault Codes (Cont.)

Inactive codes are faults that have occurred in the previous (ignition) “key ON cycles” and are now stored in memory. An “Active Code” will become an “Inactive” code when the key switch is turned to the “OFF” position.

Record all fault codes that are found. If there are any fault codes found, refer to Electronic Control System Diagnostics.

NOTE: *All current fault codes must be repaired and (cleared), before proceeding with further diagnostic testing.*

POSSIBLE CAUSES

Electronic malfunctions which can be detected by the ECM on a continuos monitor basis.

TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to fault code diagnostics.

EST Tool - Engine Off Tests

EST TOOL - ENGINE OFF TESTS

● Select “Engine Off” test from diagnostic test menu.

Faults Found	

□ See Codes.

PURPOSE

To determine if there are any electrical malfunctions that can be detected by the Electronic Control Module (ECM) “Output Circuit Check” self test.

TEST PROCEDURE

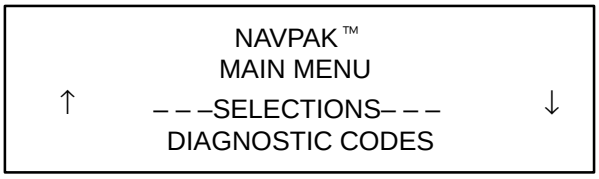
NOTE: *Access “Diagnostic Codes” menu in EST and clear all fault codes before performing engine off tests.*

Access the **“ENGINE OFF TEST”** in the **“DIAGNOSTIC TESTS”** section of the Electronic Service Tool (EST).

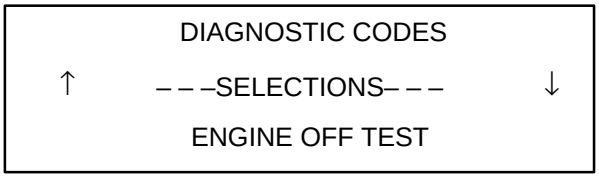
Press the **“FUNC”** key repeatedly, until the main menu appears on the screen.

EST Tool - Engine Off Tests (Continued)

Next select the **"DIAGNOSTIC TESTS"** menu by pressing the "↓" key, until **"DIAGNOSTIC TESTS"** is shown on the screen. Press **"ENTER"** to make this selection.



Press the "↓" key, until the **"ENGINE OFF TEST"** is shown on the screen. At this point, press **"ENTER"**



After the **"ENTER"** key is pressed, the EST will command the ECM to perform a [(OCC) Output Circuit Check] self test. During this test, the ECM will test the electrical continuity of the output circuits.

When the test is complete, the screen will display the number of faults found in the self test. If there are any additional faults found, press **"ENTER"** and the faults will be displayed. If there is more than one fault that was found during the test, the "↑↓" symbol will be shown on the screen. Press the "↓" key to access any additional faults. The test is repeated by selecting, "**STANDARD TEST,"** under the "**ENGINE OFF TESTS"** menu, only new faults found will be displayed as "Faults Found."

NOTE: *To repeat engine off tests, select "STANDARD TEST" in the Engine Off Test menu.*

POSSIBLE CAUSES

- Defective electrical components or circuitry.
- Injection Pressure Regulator (IPR) output circuit check fault.

TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to fault code diagnosis.

EST Tool - Injector Buzz Test

EST - INJECTOR "BUZZ TEST"

NOTE: "Engine Off Test" must be performed first, in order to gain access to the Injector "BUZZ TEST"

- Select "Injector Test" from "The Engine Off Tests" menu

Faults Found	

- ☐ See Codes.

PURPOSE

To determine if the injectors are electronically functioning correctly, by energizing each injector in a programmed sequence. The Electronic Control Module (ECM) will monitor this test and transmit fault codes if any injector(s) or electrical circuitry are not functioning properly.

TEST PROCEDURE

NOTE: *Access "Diagnostic Codes" menu in EST and clear all fault codes.*

NOTE: *Engine off test must be performed first in order to access the injector "Buzz" test.*

After the **"Engine Off Standard Test"** has been completed, press the "↓" key to access the **"INJECTOR TEST"**. If the tool is not on a menu screen, i.e. displaying of fault codes etc., press the **"FUNC"** key. This will access the **"ENGINE OFF TESTS"** menu. Press **"ENTER"** to begin the test.

ENGINE OFF TESTS
↑ – – –SELECTIONS– – – ↓
INJECTOR TEST

During this test, the injector solenoids will produce an audible clicking sound when actuated. It is possible to detect a malfunctioning injector(s) by listening for the absence of the solenoid clicking sound.

NOTE: *If fault codes were cleared before the injector "Buzz" test, fault codes displayed will be actual faults found during the test. If codes were not cleared before testing, access "inactive" fault codes from diagnostic codes menu to retrieve faults found during this test.*

At the completion of the Injector Test, any faults that have been detected will be displayed. If there is more than one fault the "↑↓" symbol will be displayed. These additional faults can be accessed by pressing the "↓" key.

Record any faults found and refer to the Electronic Control System Diagnostics.

EST Tool - Injector Buzz Test (Continued)

POSSIBLE CAUSES

- Bad wiring harness connection at injector solenoid.
- Open or shorted engine wiring harness to injector(s).
- Defective injector solenoid(s).

TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to fault code diagnosis.

STI (Audio Test) Switch - Flash Codes

STI (AUDIO TEST) SWITCH FLASH CODES

- Push down and hold Audio Test (STI) switch toggle lever, then turn the key switch to the RUN (ON) position.

Faults Found	

PURPOSE

To read faults detected by the Electronic Control Module (ECM), if the Electronic Service Tool (EST) is not available or the EST cannot receive “Self Test Input” data due to communications or component failures.

The Self Test Input (STI) switch is also the Audio Test/Panel Lights toggle switch located on the instrument panel. Pushing and holding the Audio Test (STI) switch toggle lever down while turning the ignition switch to the RUN (ON) position, will signal the ECM to start the Self Test Input diagnostics to check output circuits. If any faults are detected, the ECM will flash the “CHECK ENGINE” lamp to indicate which faults have been detected.

NOTE: *Self test input diagnostics will not flash some Fault Codes.*

STI (Audio Test) Switch - Flash Codes (Continued)

TEST PROCEDURE

Push and hold the Audio Test switch toggle lever down. Turn the ignition switch to the RUN (ON) position. **Do Not Start The Engine.** The ECM will begin to perform the self test to check the output circuits.

When the test is completed, the ECM will flash the **"COOLANT TEMPERATURE"** lamp and **"CHECK ENGINE"** lamp to signal the fault codes.

NOTE: *Fault codes can be accessed at anytime by pushing and holding the Audio Test (STI) switch toggle lever down while turning the ignition switch to the RUN (ON) position*.

To read the fault codes it will be necessary to count the number of times the **"CHECK ENGINE"** lamp flashes. The following sequence of events occur each time the Audio Test switch lever is pushed to obtain the fault codes:

1. The **"COOLANT TEMPERATURE"** lamp will flash one time to indicate the beginning of **Active** fault codes.
2. The **"CHECK ENGINE"** lamp will flash repeatedly signaling the active fault codes.

NOTE: *All fault codes are three digits and code 111 indicates "no faults" have been detected.*

3. Count the number of flashes in sequence. At the end of each digit of the code there will be a short pause. Three flashes and a pause would indicate the number 3. Therefore, two flashes, a pause, three flashes a pause, and two flashes a pause would indicate the code 232. If there is more than one fault code, the **"COOLANT TEMPERATURE"** lamp will flash once indicating the beginning of another active fault code.

After all the active codes have been flashed, the **"COOLANT TEMPERATURE"** lamp will flash twice to indicate the beginning of **INACTIVE** codes. Count the number of flashes from the **"CHECK ENGINE"** lamp. If there is more than one inactive code, the **"COOLANT TEMPERATURE"** lamp will flash once in-between each fault code.

After all codes have been sent, the **"COOLANT TEMPERATURE"** lamp will flash three times indicating "END OF MESSAGE".

To repeat transmission of fault codes, push the Audio Test switch lever down (with the key switch still in the RUN position). This action will signal the ECM to resend all stored fault codes.

If fault codes are set, refer to fault code diagnosis.

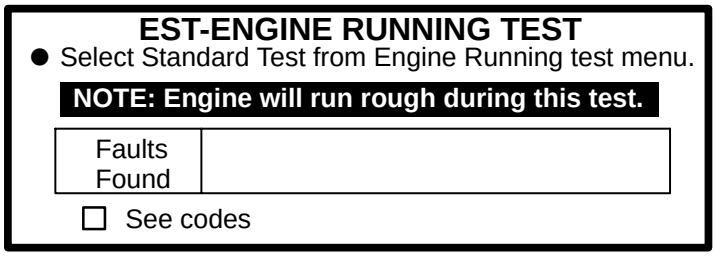
POSSIBLE CAUSES

- Electronic component or circuitry failures.

TOOLS REQUIRED

None.

EST - Engine Running Test


EST-ENGINE RUNNING TEST
● Select Standard Test from Engine Running test menu.
NOTE: Engine will run rough during this test.
Faults Found
☐ See codes

PURPOSE

To verify the engine's electronic sensors and actuators are operating properly within their specified operating ranges. The Electronic Service Tool (EST) is used to signal the Electronic Control Module (ECM) to perform the "Engine Running Test". The ECM will exercise the actuators and monitor sensor feedback signals. If a sensor or actuator problem exists, the ECM will transmit fault code(s) to the EST.

TEST PROCEDURE

⚠ WARNING

If engine is to be tested with boat out of water, the propeller must be removed to avoid injury.

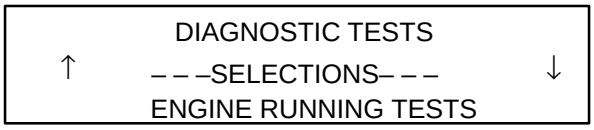
⚠ CAUTION

Avoid engine damage. Ensure that cooling water is supplied to the engine if it will be operated with the boat out of the water.

1. Start and run engine until it reaches 160° F (71° C) minimum.

NOTE: *Engine must be at least 160° F (71° C) to allow the ECM to perform an accurate test of the engine sensors and actuators. If engine coolant temperature is below self test range, the EST tool will display an "ECT Out Of Self Test Range" message.*

2. Access the "Engine Running Test" from the **"DIAGNOSTIC TESTS"** menu by pressing the **"↓"** key, until **"ENGINE RUNNING TEST"** appears on the screen. Then press the **"ENTER"** key.



The ECM will then conduct the "Engine Running Test." It will command the engine to accelerate to a pre-determined engine RPM and operate the Injection Pressure Regulator (IPR) valve.

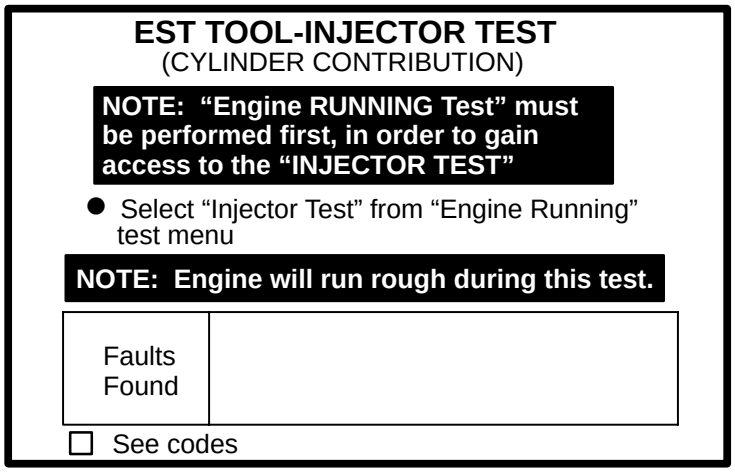
The ECM will measure the effects of actuator movement via the sensors. At the completion of the test, the EST screen will display **"00 FAULTS,"** if no faults were detected. If EST indicates faults have been detected, press the **"ENTER"** key to display the fault codes. Record fault codes and refer to the Electronic Diagnostic form EGED–200 for fault codes which were detected.

EST - Engine Running Test (Continued)

POSSIBLE CAUSES

- Defective or inoperative sensors or actuators.
- Injection Control System high pressure oil leakage.
- Defective high pressure pump
- Open or shorted wiring harness to sensors or actuators.
- Loose or corroded engine wiring harness connections at sensor or actuators.

EST Tool - Injector Test


EST TOOL-INJECTOR TEST
(CYLINDER CONTRIBUTION)
NOTE: "Engine RUNNING Test" must be performed first, in order to gain access to the "INJECTOR TEST"
Select "Injector Test" from "Engine Running" test menu
NOTE: Engine will run rough during this test.
Faults Found
See codes

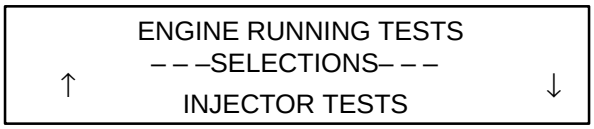
PURPOSE

To verify that all power cylinders are contributing equally.

TEST PROCEDURE

NOTE: *The "Engine Running Test" must be performed first to access the injector test.*

After the **"Engine Running Test"** has been completed, press the "↓" key from the **"ENGINE RUNNING TEST"** screen to access the **"INJECTOR TEST."** Then press the **"ENTER"** key.



NOTE: *The engine will run rough during the test.*

The Electronic Service Tool (EST) will signal the Electronic Control Module (ECM) to actuate each injector in a programmed sequence and then measure power cylinder performance.

At the completion of the test, the EST screen will display **"00 FAULTS,"** if no injector faults occurred. If EST indicates faults have been detected, press the **"ENTER"** key to display the fault codes. Record fault codes.

POSSIBLE CAUSES

- Broken compression rings, leaking or bent valves, bent push rods or connecting rods.
- Open or shorted engine wiring harness to injector(s).
- Defective injector solenoid(s)

TOOLS REQUIRED

PRO-LINK® 9000 (ZTSE-43661).

SUPPLEMENTAL DIAGNOSTICS

Refer to Electronic Control System Diagnostics.

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Fuel Pressure - Full Load

FUEL PRESSURE - FULL LOAD

- Measure at regulator block.
- Measure at full load rated speed.

Instrument	Spec.	Actual
0-160 psi (0 - 1100 kPa) Gauge	60-70 psi (414-482 kPa) @ Full load	

☐ **If pressure is low, replace fuel filter and retest.**

☐ **If pressure still low, perform transfer pump restriction test.**

NOTE: *FUEL PRESSURE (FULL LOAD) AND BOOST PRESSURE ARE "ON THE WATER TESTS." THEY MAY BE PERFORMED AT THE SAME TIME.*

PURPOSE

To determine if fuel pressure is sufficient to correctly operate the engine at full load operating condition.

NOTE: *If fuel filter is equipped with a water-in-fuel probe, check with vessel operator to determine if the water-in-fuel lamp has been illuminated during vessel operation.*

TEST PROCEDURE

NOTE: *Fuel pressure must be taken at full load. Fuel pressure may be sufficient at high idle, but may be unsatisfactory at full load operating conditions.*

1. Remove 1/8 in. pipe plug located on the fuel regulator block. Install 1/8 in. pipe fitting in place of the pipe plug.
2. Connect a line from the fitting to the 0-160 psi (0 - 1100 kPa) gauge of the Model D-200 Pressure Test Kit (ZTSE-2239), or equivalent. Start engine and run at low idle to check for fuel leaks in line to pressure gauge.

NOTE: *Bleed air from the fuel line to insure an accurate reading.*

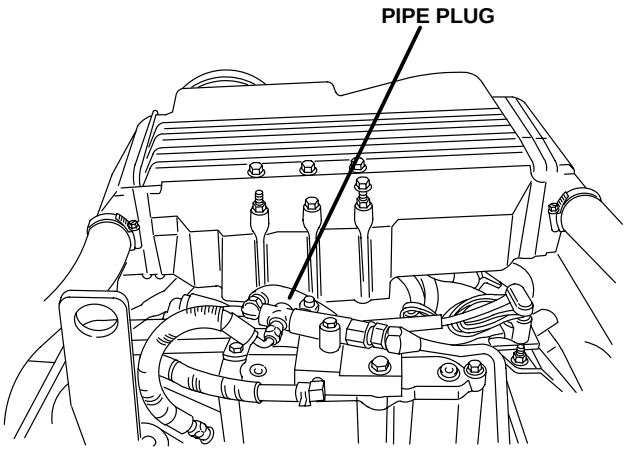
IMPORTANT: TO MEASURE FUEL PRESSURE AT FULL LOAD, VESSEL MUST BE OPERATED ON THE WATER, IN FORWARD GEAR, AND AT WIDE-OPEN-THROTTLE. IF A DYNAMOMETER IS AVAILABLE, OPERATE AT FULL RATED LOAD AND SPEED.

3. Measure fuel pressure at full load and record. **If pressure is not within specifications, replace fuel filter and re-check fuel pressure.**

Fuel Pressure - Full Load (Continued)

NOTE: *It may take a number of crank cycles to purge the air out of the fuel system after replacing the fuel filter.*

If fuel pressure remains low after replacing the filter, perform Transfer Pump Restriction Test.



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POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Replace filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Gauge Bar (PS94-831-3) or Model D-200 Pressure Test Kit (ZTSE-2239) [0 to 160 psi (0 - 1100 kPa)] fuel pressure gauge or equivalent, and appropriate line with 1/8 in. NPT fitting.

Injection Control Pressure Test

ICP PRESSURE

- Monitor ICP pressure and engine rpm with EST tool in data list mode.
  Or use breakout “TEE” and DVOM
- Refer to specifications.

Data	Spec.	Actual
Low Idle	psi/Volts	
High Idle	psi/Volts	
Full Load	psi/Volts	

☐ If pressure is low or unstable, disconnect ICP Sensor and retest.

☐ If problem is resolved, refer to ICP diagnostics.

☐ If pressure is still low or unstable, replace IPR and retest.

PURPOSE

To determine if the high pressure lube oil system is providing sufficient hydraulic pressure to operate the injectors.

TEST PROCEDURE

IMPORTANT: TEST SHOULD BE PERFORMED AT FULL LOAD IN CONJUNCTION WITH FUEL PRESSURE FULL LOAD TEST AND BOOST PRESSURE TEST.

IMPORTANT: If engine oil is aerating, it may cause the engine to idle erratically. To determine if oil is being aerated, perform this test after engine has been run under a load.

NOTE: *Turn all accessories and the key switch OFF, before connecting EST tool to ATA (American Trucking Association) diagnostic connector.*

1. Connect the Electronic Service Tool (EST) to the ATA data link connector.

NOTE: *Ensure the remote control is in Neutral.*

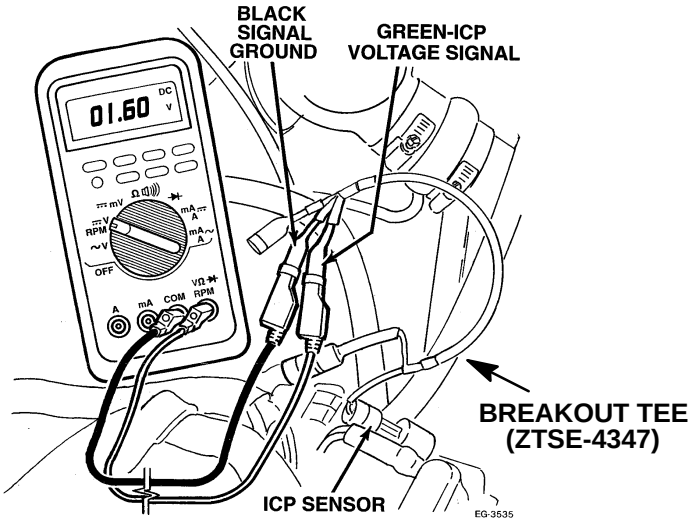
2. Start the engine and bring it to operating temperature.
3. Press the “↓” key on the EST until Navistar Engine Control Module appears on the screen. Press **ENTER**. Press “↓” key until **“**NAVPAK™” DATA LIST appears on the screen. Press **ENTER.** Press the “↓” key until INJ CONTROL PSI appears on the screen.

BATT VOLTS	12.5
ENGINE RPM	0
INJ CNTL PSI	0
BARO IN Hg.	28.8

Injection Control Pressure Test (Continued)

4. Operate engine at high idle and monitor (ICP) Injection Control Pressure for 60 seconds on the EST.
5. Read ICP pressure (voltage) and record on diagnostic form.

Normal ICP pressure is 1000-1040 psi. (6894-7170 kPa) If ICP pressure does not stabilize below 1100 psi (7583 kPa) and continues to rise while high idle speed is maintained, engine lube oil may be aerated. If this condition occurs, change oil and filter, then repeat ICP test.



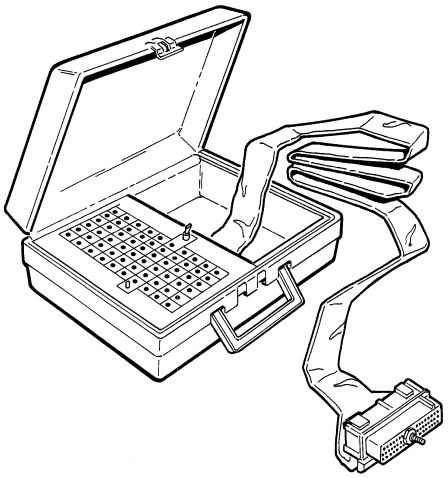
ALTERNATE METHOD OF MEASURING INJECTION CONTROL PRESSURE USING BREAKOUT “TEE”

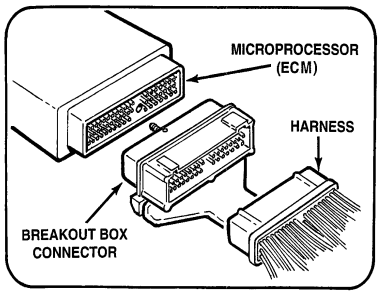
1. Remove engine harness connector at ICP sensor.
2. Connect the breakout “TEE” to the removed engine harness connector and the ICP sensor.
3. Connect DVOM leads (+Green, -Black) to the breakout “TEE” as shown.
4. Start the engine and bring it to operating temperature.
5. Operate engine at high idle and monitor (ICP) voltage for 60 seconds. Normal ICP voltage is between 1.2 to 1.6 volts. If the ICP signal voltage continues to rise as high idle speed is maintained, the engine lube oil may be aerated. Change oil and filter, then repeat ICP test at high idle.

TOOLS REQUIRED

DVOM and breakout sensor “Tee” (ZTSE-4347).

Injection Control Pressure Test (Continued)





ALTERNATE METHOD OF MEASURING INJECTION CONTROL PRESSURE USING BREAKOUT BOX

1. Connect breakout box at ECM.
2. Connect DVOM to breakout box terminal #s (+16, -19).
3. Start the engine and bring it to operating temperature.
4. Operate engine at high idle and monitor (ICP) voltage for 60 seconds. Normal ICP voltage is between 1.2 to 1.6 volts. If the ICP signal voltage continues to rise, as high idle speed is maintained, the engine lube oil may be aerated. Change oil and filter, then repeat ICP test at high idle.

POSSIBLE CAUSES

- Extended oil drain intervals. The anti-foam additives in the oil may be depleted from severe use or extended oil drain intervals.
- Wrong oil type or grade of oil.

TOOLS REQUIRED

DVOM and breakout box (ZTSE-4445).

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Fuel Pressure High Idle

FUEL PRESSURE HIGH IDLE

- Measure at regulator block.

Instrument	Spec.	Actual
0 - 160 PSI 0 - 1100 kPa) Gauge	30-65 psi (206-448 kPa) @ High idle	

☐ **If pressure is low, replace filter and retest.**

If pressure still low, perform "Transfer Pump Restriction Test".

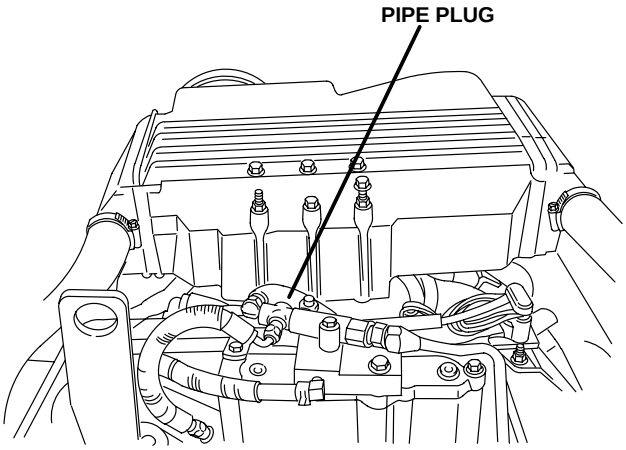
PURPOSE

To determine if fuel pressure is sufficient to correctly operate the engine.

TEST PROCEDURE

NOTE: *If fuel filter is equipped with a water-in-fuel probe, check with vessel operator to determine if the water-in- fuel lamp has been illuminated during vessel operation.*

1. Remove 1/8 in. pipe plug located on the fuel regulator block. Install 1/8 in. pipe fitting in place of the pipe plug.



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2. Connect a line from the fitting to the 0-160 psi (0-1100 kPa) gauge of the Model D-200 Pressure Test Kit (ZTSE-2239), or equivalent. Start engine and run at low idle to check for fuel leaks in line to pressure gauge.

NOTE: *Bleed air from the fuel line to insure an accurate reading.*

3. Measure fuel pressure at high idle. **If pressure is not within specifications, replace fuel filter and re-check fuel pressure at high idle.**

NOTE: *It may take a number of crank cycles to purge the air out of the fuel system after replacing the fuel filter.*

If fuel pressure remains low after replacing the filter, perform Transfer Pump Restriction Test.

Fuel Pressure High Idle (Cont.)

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Replace filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
- The fuel pump could have internal damage, i.e. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Model D-200 Pressure Test Kit (ZTSE-2239) (0 to 160 PSI fuel pressure gauge), appropriate line with 1/8” NPT fitting.

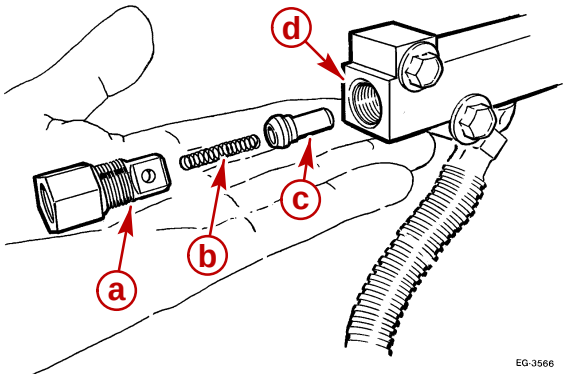
Fuel Pressure - Fuel Regulator Valve

PURPOSE

To determine if fuel regulator valve is the cause of incorrect fuel pressure that may have been apparent in previous tests, but was not resolved through testing. Proper control of the flow of return fuel past the regulator valve is essential for correct system fuel pressure.

TEST PROCEDURE

1. Remove fuel return line from adapter fitting on fuel regulator block.
2. Use needle nose pliers to remove the fuel regulator spring and valve from the regulator.



a - Fitting
b - Spring
c - Fuel Regulator Valve
d - Fuel Regulator Block

3. Inspect fuel regulator valve seating surface for damage and ensure spring is not broken.
4. Inspect inside of regulator block for dirt or debris that could prevent proper seating or functioning of the valve.

POSSIBLE CAUSES

- Fuel regulator valve seating surface damaged by improper servicing or contaminates in fuel.
- Faulty or broken fuel regulator valve spring.
- Dirt or debris in fuel system.

TOOLS REQUIRED

Hand tools and flashlight.

FUEL SYSTEM

Section 5C - Electronic Control System Diagnostics

Table of Contents

Flash Code and Circuit Index 5C-3
Diagnostic Procedures 5C-7
Inspection 5C-7
Connector Voltage Checks 5C-7
Connector Checks To Ground (-) . . . 5C-8
Harness Resistance Checks 5C-9
Operational Signal Checks 5C-9
Circuit Function and Diagnostics 5C-10
APS / IVS - Accelerator Position Sensor / Idle Validation Switch 5C-10
BARO - Barometric Pressure Sensor 5C-18
CMP - Camshaft Position Sensor . . . 5C-22
ATA Communications 5C-28
ECM - Electronic Control Module Self-Diagnostics 5C-32
Signal Function 5C-32
Fault detection/management 5C-32
Normal Operation Diagnostics 5C-33
Continuous Diagnostics 5C-33
On Demand Diagnostics (Service Diagnostics) 5C-33
ECM Internal Self-Tests 5C-33
ECM - Electronic Control Module Power Supply 5C-36
Extended Description 5C-38
ECM Diagnostics 5C-38
Troubleshooting 5C-39
Before Performing Any Tests 5C-39
ECT - Engine Coolant Temperature Sensor 5C-40
Signal Function 5C-40
Fault Detection / Management 5C-40
Function 5C-42
Operation 5C-42
ECM Diagnostics 5C-42
EOT - Engine Oil Temperature Sensor 5C-44
Signal Functions 5C-44
Fault Detection / Management 5C-44
Function 5C-46
ECM Diagnostics 5C-46
GPC - Glow Plug Controller 5C-48
Function 5C-52
Operation 5C-52
ECM Diagnostics 5C-52
IAT - Intake Air Temperature Sensor 5C-54
SIGNAL FUNCTIONs 5C-54
Fault Detection / Management 5C-54
Function 5C-56
Operation 5C-56
ECM Diagnostics 5C-56
ICP - Injection Control Pressure Sensor 5C-58
Signal Functions 5C-58
Fault Detection / Management 5C-58
Function 5C-60
Operation 5C-60
Injector Drive Circuit Operation 5C-62
Circuit Functions 5C-63
Fault Detection / Management 5C-63
Function System Description 5C-65
Injector Diagnostics 5C-65
IPR - Injection Pressure Regulator . . 5C-68
Output Functions 5C-69
Fault Detection / Management 5C-69
Function 5C-71
Operation 5C-71
ECM Diagnostics 5C-71
IPR_SYS - Injection Pressure Regulation System 5C-73
Injection Control Pressure Regulator Testing 5C-74
MAP - Manifold Absolute Pressure Sensor 5C-78
Signal Functions 5C-78
Fault Detection / Management 5C-78
Function 5C-80
Operation 5C-80
ECM Diagnostics 5C-80
STI - Self Test Input Test & Check Engine Lamp 5C-82
Signal Functions 5C-82
Check Engine Lamp 5C-82
Fault Detection / Management 5C-82
Audio Test / STI Switch 5C-84
Check Engine Lamp 5C-84
ECM Diagnostics 5C-84
Troubleshooting Self Test Input (STI) Switch 5C-85
Check Engine Lamp Malfunction . . 5C-85
Before Troubleshooting 5C-85
V Ref - Voltage Reference Circuits . . 5C-86
Circuit Functions 5C-86
Fault Detection / Management 5C-86
Function 5C-88
Operation 5C-88
ECM Voltage Reference Diagnostics 5C-88

5C

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Flash Code and Circuit Index

CODE	CIRCUIT	FAULT DESCRIPTION
111	ECM	No Fault Detected - Flash code only
112	ECM PWR	Electrical System Voltage B+ out of range HIGH
113	ECM PWR	Electrical System Voltage B+ out of range LOW
114*	ECT	Engine Coolant Temperature Signal out of range LOW
115*	ECT	Engine Coolant Temperature Signal out of range HIGH
121*	MAP	Manifold Absolute Pressure Signal out of Range HIGH
122*	MAP	Manifold Absolute Pressure Signal out of range LOW
123*	MAP	Manifold Absolute Pressure In Range Fault
124*	ICP	Injection Control Pressure Signal out of range LOW
125*	ICP	Injection Control Pressure Signal out of range HIGH
131*	APS / IVS	Accelerator Position Signal out of range LOW
132*	APS / IVS	Accelerator Position Signal out of range HIGH
133*	APS / IVS	Accelerator Position Signal in-range fault
134*	APS / IVS	Accelerator Position and Idle Validation disagree
135*	APS / IVS	Idle Validation Switch circuit fault
143	CMP	Wrong number of CMP signal transitions per cam revolution
144	CMP	CMP Signal noise detected
145*	CMP	CMP Signal inactive while ICP has increased
151	BARO	Barometric Pressure Signal out of range HIGH
152	BARO	Barometric Pressure Signal out of range LOW
154	IAT	Intake Air Temperature Signal out of range LOW
155	IAT	Intake Air Temperature Signal out of range HIGH
211*	EOP	Engine Oil Pressure Signal out of range LOW
212*	EOP	Engine Oil Pressure Signal out of range HIGH
225	EOP	Engine Oil Pressure Signal in range fault

* - Indicates CHECK ENGINE LAMP on when fault is set.

Flash Code and Circuit Index

CODE	CIRCUIT	FAULT DESCRIPTION
231	DCL / ATA	ATA Data Communication Link Error
241	IPR	Injection Control Pres. Regulator OCC Self Test failed
251	GPC	Glow Plug Controller OCC Self Test failed
252	GPC	Glow Plug Lamp OCC Self Test failed
311*	EOT	Engine Oil Temperature Signal out of range LOW
312*	EOT	Engine Oil Temperature Signal out of range HIGH
313	EOP**	Engine Oil Pressure below warning level
314	EOP**	Engine Oil Pressure below critical level
315*	CMP	Engine Speed (Tach rpm) limit exceeded
316	ECT	Engine Coolant Temperature Unable to Reach commanded set point
321	ECT**	Engine Coolant Temperature above warning level
322	ECT**	Engine Coolant Temperature above critical level
323	ECL	Engine Coolant Level below warning / critical level
324		Idle Shutdown Timer Enabled Engine Shutdown
325	ECT	Power reduced, matched to cooling system performance
331*	IPR	Injection Control Pressure above system working range
332*	ICP	Injection Control Pressure above spec. with engine OFF
333*	IPR System	Injection Control Pressure above / below desired level
334*	IPR System	ICP unable to achieve setpoint in time (poor performance)
335*	IPR System	ICP unable to build pressure during cranking

* - Indicates CHECK ENGINE LAMP on when fault is set.

** - Faults only available if Engine Protection is enabled.

Flash Code and Circuit Index

CODE	CIRCUIT	FAULT DESCRIPTION
421	INJ	Cylinder 1: High Side to Low Side Open
422	INJ	Cylinder 2: High Side to Low Side Open
423	INJ	Cylinder 3: High Side to Low Side Open
424	INJ	Cylinder 4: High Side to Low Side Open
425	INJ	Cylinder 5: High Side to Low Side Open
426	INJ	Cylinder 6: High Side to Low Side Open
427	INJ	Cylinder 7: High Side to Low Side Open
428	INJ	Cylinder 8: High Side to Low Side Open
431	INJ	Cylinder 1: High Side Shorted to Low Side
432	INJ	Cylinder 2: High Side Shorted to Low Side
433	INJ	Cylinder 3: High Side Shorted to Low Side
434	INJ	Cylinder 4: High Side Shorted to Low Side
435	INJ	Cylinder 5: High Side Shorted to Low Side
436	INJ	Cylinder 6: High Side Shorted to Low Side
437	INJ	Cylinder 7: High Side Shorted to Low Side
438	INJ	Cylinder 8: High Side Shorted to Low Side
451	INJ	Cylinder 1: High Side Shorted to Ground or VBAT
452	INJ	Cylinder 2: High Side Shorted to Ground or VBAT
453	INJ	Cylinder 3: High Side Shorted to Ground or VBAT
454	INJ	Cylinder 4: High Side Shorted to Ground or VBAT
455	INJ	Cylinder 5: High Side Shorted to Ground or VBAT
456	INJ	Cylinder 6: High Side Shorted to Ground or VBAT
457	INJ	Cylinder 7: High Side Shorted to Ground or VBAT
458	INJ	Cylinder 8: High Side Shorted to Ground or VBAT

* - Indicates CHECK ENGINE LAMP on when fault is set.

Flash Code and Circuit Index

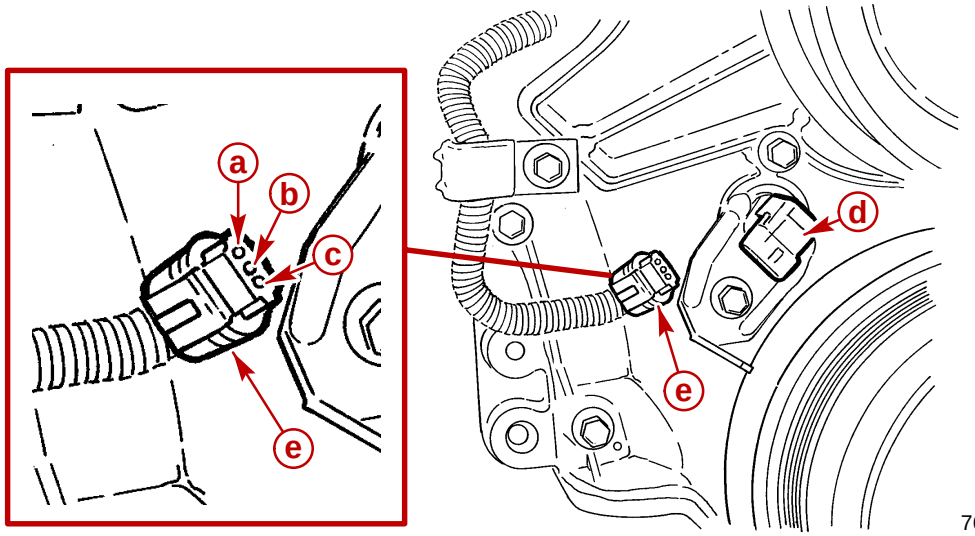
CODE	CIRCUIT	FAULT DESCRIPTION
461	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 1
462	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 2
463	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 3
464	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 4
465	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 5
466	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 6
467	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 7
468	Perf. Diag.	Cyl. Contribution Test Failure - Cyl 8
513*	INJ	Low Side to Bank 1 Open
514*	INJ	Low Side to Bank 2 Open
515*	INJ	Bank 1 Low Side Short to Ground or B+
521*	INJ	Bank 2 Low Side Short to Ground or B+
524*	INJ	Both High Side Switches shorted together
525*	ECM	Injector Driver circuit fault
612*	CMP	Incorrect ECM installed for CMP (timing) wheel
614*	ECM	EFRC / EECM ING configuration mismatch
621*	ECM	Engine using MFG. Default rating program engine
622*	ECM	Engine using Field Default rating
623*	ECM	Invalid Engine Rating Code; Check ECM programming
624	ECM	Field default active
626	ECM_PWR	Unexpected reset fault
631*	ECM	ROM (Read Only Memory) Self Test fault
632	ECM	RAM Memory-CPU Self Test Fault
655	ECM	Programmable Parameter list level incompatible
661	ECM	RAM Programmable Parameter list corrupt
664	ECM	Calibration level incompatible
665	ECM	Programmable Parameter memory content corrupt

* - Indicates CHECK ENGINE LAMP on when fault is set.

Diagnostic Procedures

Inspection

The basic diagnostic procedure recommended for most sensor and actuator circuits is to disconnect the harness at the connector and inspect for corrosion, bent pins, spread pins or any condition that could cause a loose or intermittent connection.



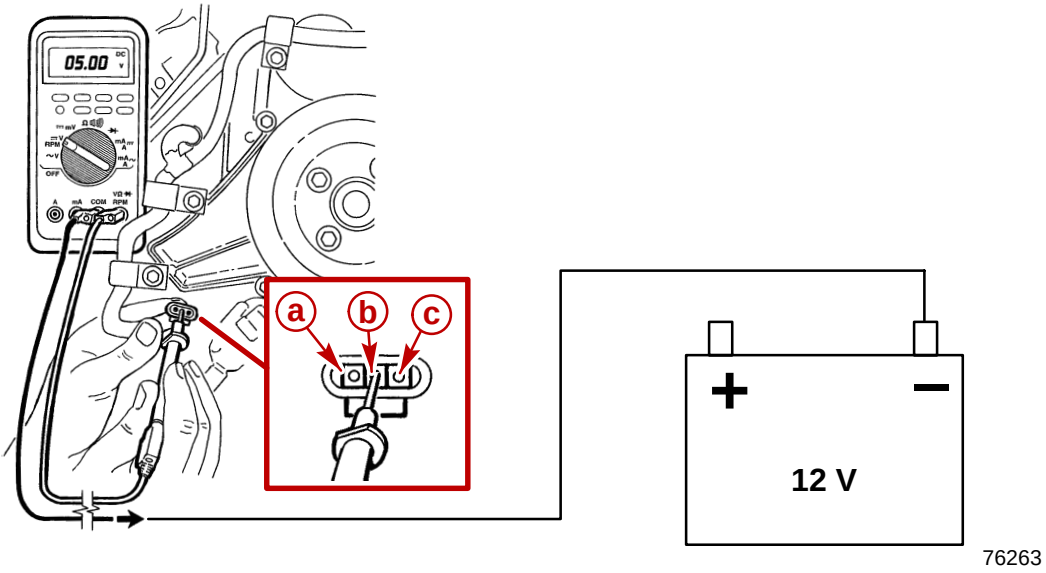
a - Terminal “A”
b - Terminal “B”
c - Terminal “C”
d - CMP Sensor
e - Harness Connector

Connector Voltage Checks

Turn the ignition key to the RUN (ON) position and measure if the expected voltages are present at the connector. On circuits with expected voltages, this test will verify the integrity of that circuit. On circuits without an expected voltage, this test will determine if that circuit is shorted or mis-wired to a voltage source.

- Signal ground (marked “A” on all engine sensor harness connectors) should measure less than .25 volts.
- V Ref should measure 5.00 volts ± .50 volts. If this is higher or lower than expected, disconnect sensors one at a time to determine if a sensor is biasing the circuit and refer to V Ref procedures.

Connector Voltage Checks (Continued)



Measuring Connector Voltage

a - Terminal “A”
b - Terminal “B”
c - Terminal “C”

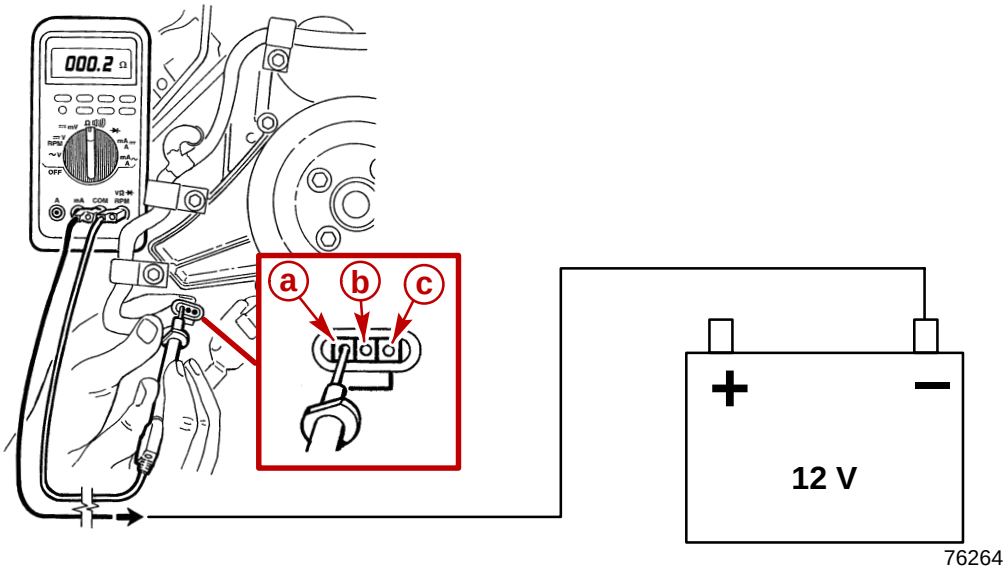
- Sensor signal lines will measure 0 to .25 volts if the circuit is designed to “pull down” when disconnected, or a higher voltage (normally 4.6 to 5, or 12 volts) if it is designed as a “pull up circuit.” A “pull up” signal circuit that measures the expected value normally indicates a good circuit.
- Actuator circuits may be either on / off type circuits (normally 12 volts) or pulse width modulated circuits (12 volts controlled by a % duty cycle).

Connector Checks To Ground (–)

The second step is to measure the resistance of all wiring harness connectors to ground (preferably the negative battery cable) to determine if a short to ground condition is present. **It is important that during this test all accessories be turned off, current flow in the system will affect resistance readings. If the reading is fluctuating greatly, disconnect the battery and measure to the negative battery cable.**

- Signal ground (marked “A” on all engine sensor harness connectors) should measure less than 5 ohms. (Signal ground on sensor connectors vary.)
- The V Ref and signal lines, with the processor connected, will normally measure greater than 1000 ohms.

- Power ground on an actuator circuit should measure less than 5 ohms. The control side of an actuator circuit will normally measure greater than 1000 ohms.



Measuring Resistance to Ground

a - Terminal “A”
b - Terminal “B”
c - Terminal “C”

Harness Resistance Checks

Harness resistance tests are performed when a circuit is suspected of having high resistance or being open. These tests are performed with the breakout box connected and by measuring resistance from the sensor connector end to the processor connector. If an open circuit or high resistance is encountered, the problem is most easily isolated by separating the circuit at the interim connectors (normally the Deutsch connector on the valve cover or the cowl) and measuring resistance through both halves of the circuit.

Operational Signal Checks

These checks are made with the breakout box installed and are normally measuring a signal voltage or frequency. They are useful for determining an in range type fault or an intermittent connection.

In the case of an intermittent fault, monitoring a suspected circuit and recreating the environmental or physical conditions that caused the complaint will help verify if a problem is in a particular circuit.

It is critical when measuring the signal level of a circuit to understand it’s function and whether it is a analog voltage, digital frequency, sine wave or digital communication signal. A standard Digital Volt Ohm Meter (DVOM) has certain limitations in measuring any circuit that has a frequency.

Circuit Function and Diagnostics

NOTE: *The symbols < & > are used on each diagnostic circuit page. They are defined as follows:*

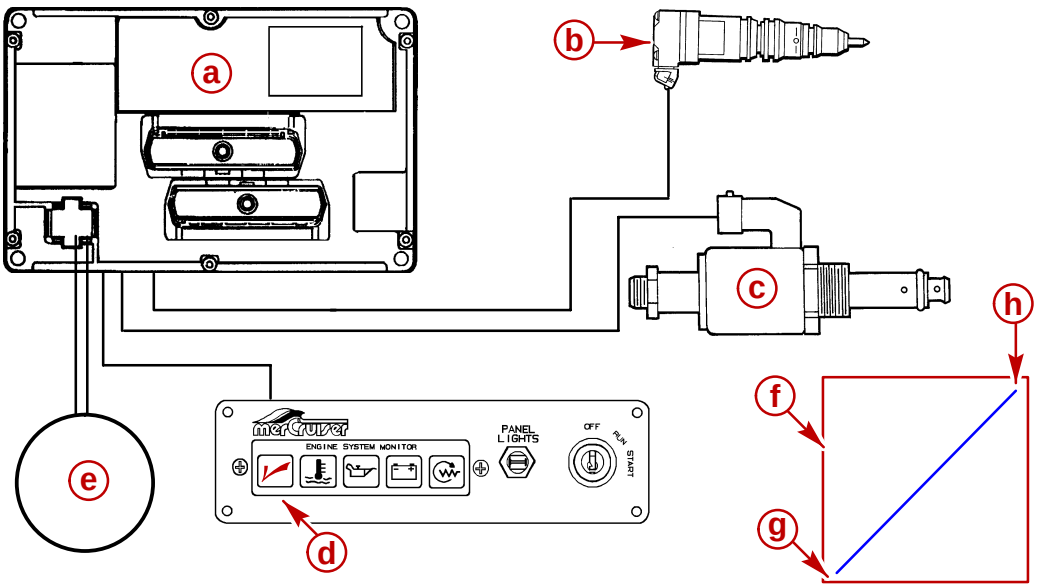
(<) Indicates a value less than

(>) Indicates a value greater than

Example: < 5 ohms = less than 5 ohms

Example: > 5 ohms = more than 5 ohms

APS / IVS - Accelerator Position Sensor / Idle Validation Switch



76256

a - ECM
b - Fuel Quantity and Timing Control (Injector)
c - Injection Control Pressure Regulator (IPR)
d - Check Engine Lamp
e - APS / IVS
f - APS / IVS Signal (Analog Voltage) Graph
g - 0 Volts (0% Throttle)
h - 5 Volts (Wide Open Throttle / 100% Throttle)

APS / IVS - Accelerator Position Sensor / Idle Validation Switch (Continued)

SIGNAL FUNCTION

The Accelerator Position Sensor (APS) is a potentiometer type sensor which, when supplied with a 5 volt reference signal from the Electronic Control Module (ECM), provides a linear analog voltage signal that indicates the driver's demand for power.

The Idle Validation Switch (IVS) is a 0/12 volt switch that provides the ECM with a redundant signal to verify when the lever is in the idle position.

Fuel Quantity and Timing Control - The APS signal is used in calculating desired fuel quantity and injector timing.

Injection Control Pressure - Accelerator position is one of the controlling variables in the calculation of desired injection control pressure.

FAULT DETECTION / MANAGEMENT

Any detected malfunction of the APS or IVS sensor circuit will illuminate the CHECK ENGINE lamp.

An APS signal that is detected out of range high or low by the ECM will cause the engine to ignore the APS signal and will only allow the engine to operate at low idle.

If a disagreement in the state of IVS and APS is detected by the ECM and the ECM determines that it is an IVS fault, the ECM will only allow a maximum of 50% APS to be commanded.

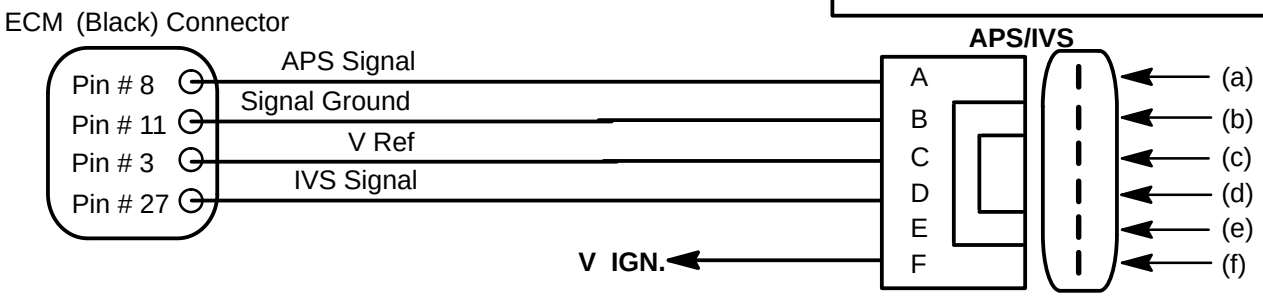
If a disagreement in the state of IVS and APS is detected by the ECM and the ECM can not discern if it is an APS or IVS fault, or if it is an APS fault, the engine will be allowed to operate at low idle only.

APS / IVS - Accelerator Position Sensor / Idle Validation Switch (Continued)

Accelerator Position Sensor & Idle Validation Switch (APS / IVS)

APS/IVS

Fault Codes:
131 APS signal out of range low
132 APS signal out of range high
133 APS signal in-range fault
134 APS and IVS disagree
135 Idle validation switch circuit fault



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks (Check with Sensor Connector Disconnected and Ignition Key ON)		
Test Points	Spec.	Comments
A to Grd.	0 – .25 volts	If greater than .25 volts, signal ground wire is shorted to V Ref or battery
B to Grd.	0 volts	Signal ground no voltage expected.
C to Grd.	5 ± .5 volts	V Ref check key on, if V Ref not present check open/short to grd, see V Ref circuit.
D to Grd.	0 – .25 volts	If greater than .25 volts, signal ground wire is shorted to V Ref or battery
F to Grd.	12 ± 1.5 volts	< 10.5 v check for poor connection, 0v check for open/short to grd circuit or blown fuse.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected, Positive Battery Cable Disconnected & Ignition key OFF)

Test Points	Spec.	Comments
A to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
B to Grd.	< 5 ohms	Resistance to chassis ground, check with key off, greater than 5 ohms harness is open.
C to Grd.	> 500 ohms	Resistance less than 500 ohms indicates a short to ground.
D to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
F to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground, with Fuse F17 removed.

Harness Resistance Checks (Check with breakout box installed on chassis harness only)

Test Points	Spec.	Comments
#8 to A	< 5 ohms	Resistance from 60 pin connector to harness connector – APS signal
#11 to B	< 5 ohms	Resistance from 60 pin connector to harness connector – Signal ground
#3 to C	< 5 ohms	Resistance from 60 pin connector to harness connector – V Ref
#27 to D	< 5 ohms	Resistance from 60 pin connector to harness connector – IVS signal
F17 to F	< 5 ohms	Resistance from V IGN. power to harness connector

	APS Test Points (+) #8 to (–) #11		IVS Test Points (+) #27 to (–) #11		**Operational Voltage Checks (Check with breakout box and the EST tool installed key in RUN (ON)**
Position	Voltage	% APS	Voltage	% APS	Comments
Low Idle	.25 to .8V	0 %	0 Volts	0 %	IVS voltage should toggle just off low idle position.
High Idle	3 to 4.4V	98–102%	12 ± 1.5 volts	98–102%	If APS measures only 50% and voltage signal in spec., IVS fault detected.

Fault Code Descriptions

131 = APS signal was less than 0.146 volts for more than 0.5 seconds *
132 = APS signal was greater than 4.55 volts for more than 0.5 seconds *
133 = APS signal in–range fault *
134 = APS and IVS disagree *
135 = Idle validation switch circuit fault – 50% APS only.
*** IF FAULT CODE IS SET, ENGINE OPERATION WILL DEFAULT TO RUN AT LOW IDLE SPEED ONLY.**

APS / IVS - Accelerator Position Sensor / Idle Validation Switch (Continued)

APS / IVS EXTENDED SYSTEM DESCRIPTION

The D7.3L engine uses an electronic accelerator assembly that includes an Accelerator Position Sensor (APS) and Idle Validation Switch (IVS). These two functions are integrated into one component mounted on the engine.

The engine Electronic Control Module (ECM) determines the position of the accelerator by processing the input signals from the Accelerator Position Sensor (APS) and Idle Validation Switch (IVS).

ACCELERATOR POSITION SENSOR (APS)

Refer to circuit diagram for the following discussion.

The ECM sends a regulated 5 volt signal through ECM connector terminal 3 to APS connector terminal C. The APS then returns a variable voltage signal (depending on throttle position) from APS connector terminal A to the ECM at terminal 8. The APS is grounded from connector terminal B to the ECM signal ground terminal 11.

APS AUTO-CALIBRATION

The ECM learns the lowest and highest positions by reading and storing the minimum and maximum voltage levels from the APS. In this manner the ECM “auto-calibrates” the system to allow maximum sensitivity. The ECM auto-calibrates as the key is turned to the RUN (ON) position, but when the key is turned OFF, these values are lost. When the key is turned to RUN (ON) again, this process starts over. When the throttle cable is disconnected (or new one installed), it does not need to be calibrated, as the calibration happens when the key is turned to RUN (ON) position.

IDLE VALIDATION SWITCH (IVS)

The ECM expects to receive one of two signals through ECM connector terminal 27 from APS/IVS connector terminal D:

- 0 volts when the throttle is at the idle position.
- 12 volts when the throttle is advanced.

The Idle Validation Switch receives 12 volt ignition voltage from 10A fuse. When the throttle lever is NOT in the idle position (throttle applied), the IVS sends a 12 volt signal to the ECM.

The ECM compares the inputs it receives at terminals 8 and 27 from the APS/IVS to verify when the pedal is in the idle position. If the APS signal at terminal 8 indicates throttle is being applied, then the ECM expects to see 12 volts at IVS terminal 27. If the APS signal at terminal 8 indicates throttle is not applied, then the ECM expects to see 0 volts at the IVS terminal 27. The timing process is critical between the APS and the IVS sensors. For this reason, it is very difficult to determine if the APS/IVS assembly is working properly using a volt-ohmmeter.

APS / IVS - Accelerator Position Sensor / Idle Validation Switch (Continued)

ECM DIAGNOSTICS

When the key is in the RUN (ON) position, the ECM continuously monitors the APS / IVS circuits for expected voltages. It also compares the APS and IVS signals for conflict. If the signals are not what the ECM expects to see, Fault codes will be set.

FLASH CODE *131*

ATA Code PID 91 FMI 4 -

ECM: *APS Out of Range Low*

The ORL (out of range low) code 131 is set if the ECM detects a voltage lower than 0.146 volts at terminal 8. This code is displayed by either the Pro-link® EST or using the Check Engine Lamp to flash codes.

When code 131 is active, the ECM restricts engine speed to idle and turns the Check Engine Lamp ON. If the condition causing code 131 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume. If code 131 is active, perform Testing APS Circuits.

Possible causes include:

- A short to ground.
- An open circuit.

FLASH CODE *132*

ATA Code PID 91 FMI 3 -

ECM: *APS Out Of Range High*

The ORH (out of range high) code 132 is set if the ECM detects a voltage greater than 4.56 volts at terminal 47. This code is displayed by either the Pro-link® EST or using the Check Engine Lamp to flash codes.

Possible causes include:

- A short to V Ref.
- 12 volts in circuit 40F.

FLASH CODE *132*

ATA Code PID 91 FMI 3 -

ECM: *APS Out Of Range High* (Continued)

When code 132 is active, the ECM restricts engine speed to idle and turns the Check Engine Lamp ON. If the condition causing code 132 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume. If code 132 is active, perform Testing APS Circuits.

APS / IVS - Accelerator Position Sensor / Idle Validation Switch (Continued)

FLASH CODES *133, 134 And 135*

APS IN-RANGE Faults

The ECM checks the voltage output of the APS by comparing the APS signal with the IVS signal. APS and IVS signals can disagree in two cases: (1) The APS signal indicates the pedal is pressed down to accelerate, but the IVS signal indicates idle position. (2) The APS signal indicates the pedal has been released to allow the engine to return to idle, but the IVS signal indicates off-idle position of the pedal.

If the ECM detects either of the above conditions, the ECM attempts to isolate the source of conflict. If code(s) 133, 134 and/or 135 are active, perform Testing IVS Circuits and Testing APS Circuits.

FLASH CODE *133*

ATA Code PID 91 FMI 2 -

ECM: *APS In Range Fault*

If the IVS signal is changing and the APS signal is constant, the ECM assumes APS is the conflict source and sets code 133. Engine rpm is restricted to idle and the Check Engine Lamp is turned ON.

FLASH CODE *134*

ATA Code PID 91 FMI 7—

ECM: *APS / IVS Disagree*

If neither the APS or IVS is changing, or both are changing or the ECM cannot determine the faulty code in specified time, then code 134 is set, engine rpm is restricted to idle and the Check Engine Lamp is turned ON.

FLASH CODE *135*

ATA Code SID 230 FMI 11-

ECM: *IVS Circuit Fault*

If the APS is changing and IVS is constant, the ECM assumes IVS is the conflict source and sets flash code 135. In this case the ECM limits the APS signal to a lower value, which provides less than full rpm, but does not limit engine rpm to idle. The Check Engine Lamp is not turned ON.

Note that codes 133, 134 and 135 are caused by an intermittent condition, the codes remain ACTIVE until the vehicle has been shutdown and restarted. They do not recover without cycling the key switch.

APS / IVS - Accelerator Position Sensor / Idle Validation Switch (Continued)

TROUBLESHOOTING

The APS and IVS circuits operate with low current levels. When troubleshooting, pay special attention to the connectors.

BEFORE PERFORMING ANY TEST

Inspect connectors for pushed back, damaged, corroded or dirty terminals, as well as making sure that the terminals and wires are properly crimped. Make sure the connectors are properly joined together. Also check for any damage to the wiring and make sure system grounds are clean and tight.

TESTING APS / IVS CIRCUITS

If flash codes 131 or 132 are present, perform Testing APS Circuits. If flash codes 133, 134 or 135 are present, perform Testing IVS Switch & Circuits.

These tests systematically check the APS and IVS circuits for:

A. Short circuits to ground.

B. Short circuits to unwanted voltage sources.

C. Open circuits or excessive circuit resistance.

D. Proper feeds and grounds.

NOTE: *The tests performed on the accelerator assembly check for shorts, opens and correct resistance values, but do not check for proper timing between the two functions. If all of the circuits between the ECM and the accelerator assembly check good, then the APS/IVS accelerator switch should be replaced.*

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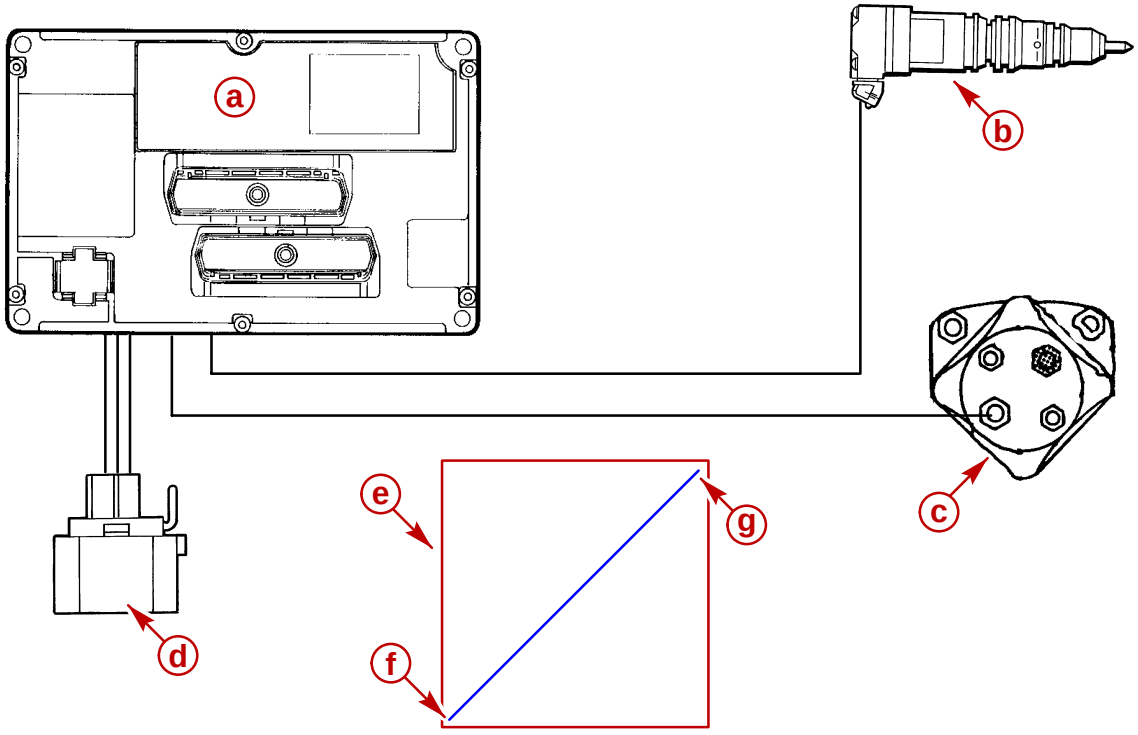
BARO - Barometric Pressure Sensor



EG–7373

a - ECM
b - Fuel Quantity and Timing Control (Injectors)
c - Glow Plug Rely
d - BARO Sensor
e - BARO Signal (Analog Voltage) Graph
f - 0 Volts (Low Pressure, High Altitude)
g - 5 Volts (High Pressure, Low Altitude)

SIGNAL FUNCTIONS

The BARO (Barometric Pressure) sensor is a variable capacitance sensor that when supplied with a 5 volt reference signal from the ECM produces a linear analog voltage signal that indicates pressure.

Timing Control – The BARO signal is used to determine altitude to adjust timing and fuel quantity to optimize engine operation and control smoke throughout all altitude conditions.

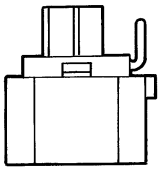
Glow Plug Control – The BARO signal is one of the variables used to calculate glow plug ON time. At higher altitudes, glow plug ON time is increased to insure faster clean up of start-up smoke.

FAULT DETECTION / MANAGEMENT

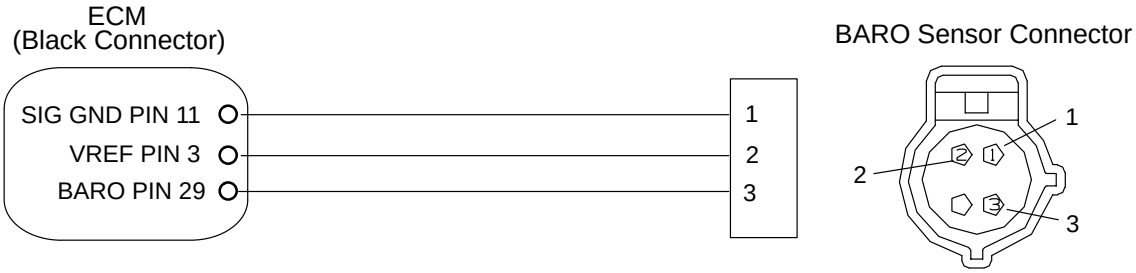
A BARO signal that is detected out of range high or low by the ECM will cause the ECM to ignore the BARO signal and use the Manifold Absolute Pressure (MAP) signal generated at low idle as an indication of barometric pressure. If a MAP fault is detected, the BARO will default to 29.6 in. Hg. of barometric pressure.

BARO - Barometric Pressure Sensor (Continued)

Barometric Pressure Sensor (BARO)



Fault Codes:
151 Out of Range High
152 Out of Range Low



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks

(Check with sensor connector (406) disconnected, Ignition Key ON, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< than .25v	If voltage is greater than .25v, signal wire is shorted to V Ref or battery.
B to Grd.	5 ± .5 volts	V Ref, check with key in RUN (ON), if voltage not in spec., see V Ref circuit.
C to Grd.	< than .25v	If voltage is greater than .25v, signal wire is shorted to V Ref or battery.

Connector Checks to Chassis Ground

(Check with Sensor Connector (406) Disconnected, Positive Battery Cable disconnected and Ignition key off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground, check with key OFF, less than 5 ohms the harness is open.
B to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks

(Check with breakout box installed on chassis harness only)

Test Points	Spec.	Comments
#11 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector – Signal ground
#3 to B	< 5 ohms	Resistance from sensor connector to 60 pin connector – V Ref
#29 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector – BARO signal

Test Points (+) #29 to (–) #11		**Operational Voltage Checks (Check with breakout box installed in line with the ECM)**	
Voltage	In. Hg.	kPA	Comments
4.89	31.0905	105	High atmospheric pressure
4.60	29.61	100	Normal atmospheric pressure at sea level
2.60	17.766	60	Normal atmospheric pressure at 10,000 feet.

Fault Code Descriptions

151 = Signal voltage was greater than 4.95 volts for more than 1.0 seconds.
152 = Signal voltage was less than 1.0 volts for more than 1.0 seconds.

BARO - Barometric Pressure Sensor (Continued)

EXTENDED DESCRIPTION BAROMETRIC PRESSURE SENSOR

Refer to circuit diagram on previous page for the following discussion.

BAROMETRIC PRESSURE SENSOR (BARO) OPERATION

The ECM sends a regulated 5 volt signal from ECM connector terminal 3 to BARO connector terminal 2. The BARO sensor returns a variable voltage signal (represents atmospheric pressure) from BARO connector terminal 3 to the ECM at terminal 29. The BARO sensor is grounded from connector terminal 1 to the ECM signal ground terminal 11.

ECM DIAGNOSTICS

The ECM continuously monitors the signal from the BARO sensor to ECM terminal 29. If the signal is out of the expected range, a fault is logged (check Engine Lamp does NOT turn on) and the ECM uses the Manifold Absolute Pressure (MAP) signal generated at low idle to determine barometric pressure.

FLASH CODE *151*

ATA CODE PID 108 FMI 3

ECM: *BARO Signal Out Of Range High*

BARO signal greater than 4.95 volts for more than 1 second.

FLASH CODE *152*

ATA CODE PID 108 FMI 4

ECM: *BARO Signal Out Of Range Low*

BARO signal less than 1.0 volt for more than 1 second**.**

TROUBLESHOOTING

The BARO circuits operate with low current levels. When troubleshooting, pay special attention to the connectors.

BEFORE PERFORMING ANY TEST

Inspect connectors for pushed back, damaged, corroded or dirty terminals, as well as making sure that the terminals and wires are properly crimped. Make sure the connectors are properly joined together. Also check for any damage to the wiring and make sure system grounds are clean and tight.

TESTING APS / IVS CIRCUITS

NOTE: *If fault codes indicate a problem is also present with the APS / IVS system, troubleshoot that system before performing the following test.*

- If BARO flash code 151 or 152 is active, perform Testing Barometric Pressure Sensor Circuits.

This test systematically checks the BARO circuits for:

A. Short circuits to ground.

B. Short circuits to unwanted voltage sources.

C. Open circuits or excessive circuit resistance.

D. Proper feeds and grounds.

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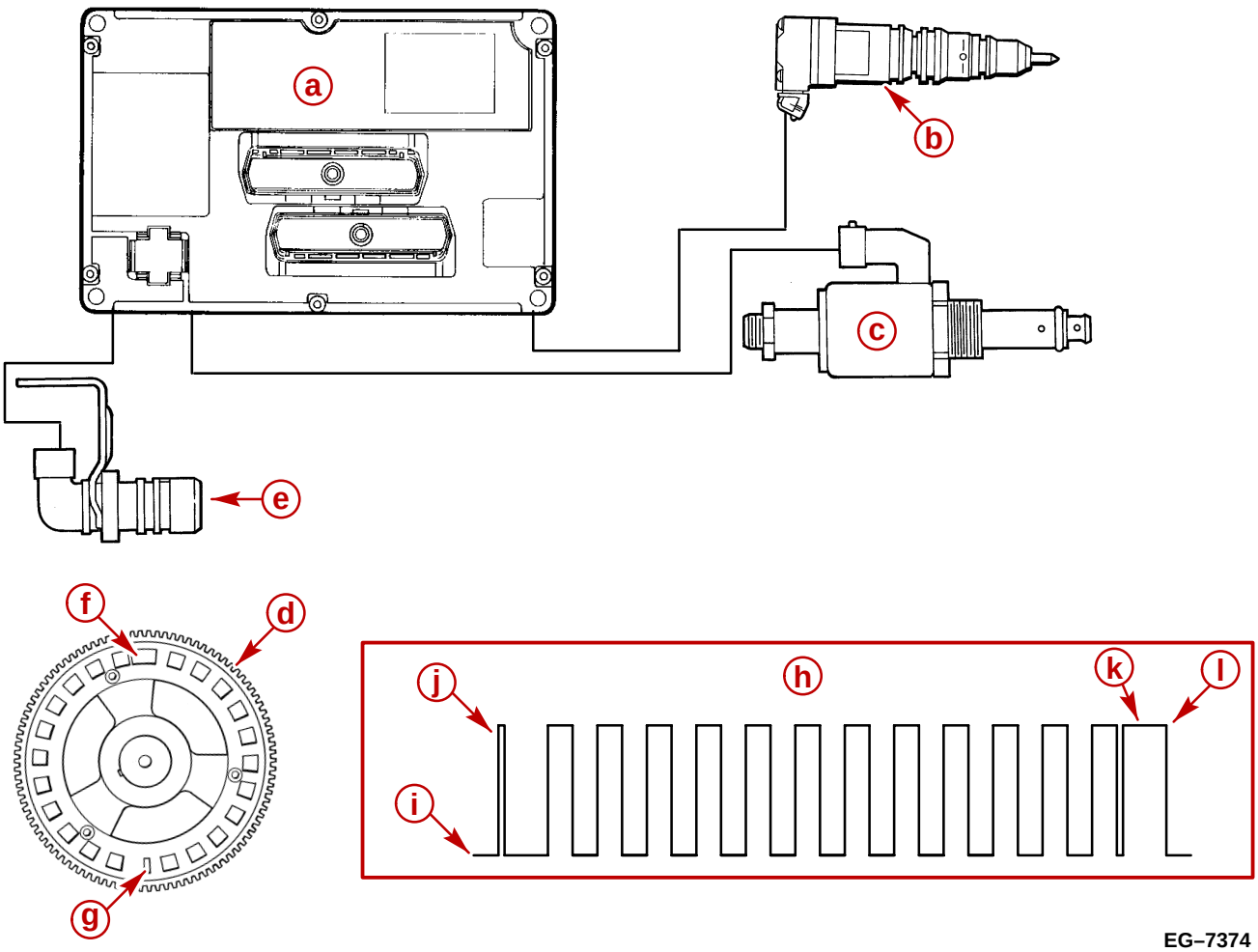
CMP - Camshaft Position Sensor



EG–7374

a - ECM
b - Fuel Quantity and Timing Control (Injectors)
c - Injection Control Pressure Regulator
d - Timing Sensor Disk (Located On The Face Of Camshaft Gear)
e - CMP Sensor
f - Wide Window - #1 Cylinder
g - Narrow Window - #4 Cylinder
h - CMP Signal (Digital Frequency)
i - .2 - 2 Volts
j - #1 Cylinder
k - #4 Cylinder
l - 5 Volt

CMP - Camshaft Position Sensor (Continued)

SIGNAL FUNCTIONS

The CMP (Camshaft Position) sensor is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through its magnetic field. The frequency of the windows passing by the sensor as well as the width of selected windows allows the ECM to detect engine speed and position.

Engine Speed - Is determined by counting 24 windows on the timing sensor disk each camshaft revolution.

Fuel Timing Control - The position of cylinder #1 is determined by distinguishing a narrow vane on the camshaft timing sensor disk.

Engine Mode Selection - Allows the ECM to discern when the engine is in the off, crank or run mode.

Injection Control Pressure - Engine speed is one of the controlling variables in the calculation of desired injection control pressure.

Exhaust Back Pressure - Exhaust back pressure control is a function of engine speed and load.

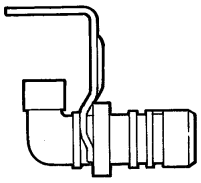
Fuel Quantity Control/Torque Limiting - Engine torque and fuel is controlled and is dependent on engine speed. Fuel quantity is determined by engine speed.

FAULT DETECTION / MANAGEMENT

An inactive CMP signal during cranking is detectable by the ECM. An inactive CMP signal will cause a no start condition. Electrical noise can also be detected by the ECM, if the level is sufficient to effect engine operation a corresponding fault code will be set. ***The engine will not operate without a functioning CMP signal.***

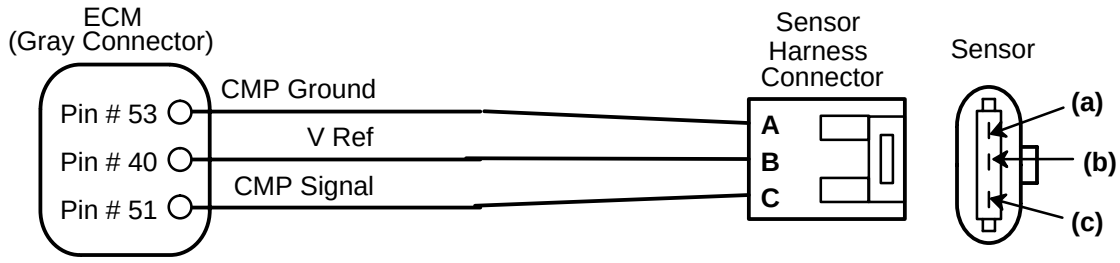
CMP - Camshaft Position Sensor (Continued)

Camshaft Position Sensor (CMP)



Fault Codes:

143 CMP/SYNC Counts incorrect
144 Noise Rejection
145 Inactive CMP sensor
612 Incorrect ECM/Timing Wheel



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks
Check with sensor connector disconnected, Ignition Key ON, all accessories OFF)

Test Points	Spec.	Comments
A to Grd.	0 volts	No voltage expected
B to Grd.	5 ± .5 volts	V Ref, check with key in RUN (ON), V Ref not present check open/short to grd #40 to B, see V Ref ckt.
C to Grd.	5 ± .5 volts	If < than 4.5v check for poor connection, if 0v check for open/short to grd circuit.

Connector Checks to Chassis Ground
(Check with Sensor Connector (406) Disconnected, Positive Battery Cable disconnected and Ignition key OFF)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground, check with key off, > than 5 ohms the harness is open.
B to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks
(Check with breakout box installed on engine harness only with ignition key OFF)

Test Points	Spec.	Comments
#53 to A	< 5 ohms	Resistance from harness connector to 60 pin connector – Signal grd (CMP) has dedicated grd circuit
#40 to B	< 5 ohms	Resistance from harness connector to 60 pin connector – V Ref
#51 to C	< 5 ohms	Resistance from harness connector to 60 pin connector – CMP signal

Test Points (+) #51 to (–) #53		**Operational Voltage Checks (Check with breakout box installed in line with the ECM and ignition key in RUN (ON)**
Voltage	Position	Comments
5 ± .5 v	Vane	With the breakout box installed, the CMP sensor and ECM connected, bar engine by hand
.2 to 2v	Window	The CMP signal voltage should change voltage state as timing wheel on cam is rotated.

Fault Code Descriptions

143 = Incorrect number of sync to transition counts detected, possible intermittent CMP sensor / circuit fault
144 = Electrical noise detected, check wire routing and grounds
145 = Inactive CMP signal detected during engine cranking when ICP pressure was sufficient for starting
612 = ECM / target disk mismatch detected (wrong ECM Programming / Installed)
315 = Engine rpm exceeded 3000 RPM.

CMP - Camshaft Position Sensor (Continued)

CAMSHAFT POSITION SENSOR (CMP) EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes a Camshaft Position Sensor (CMP). This sensor provides the Electronic Control Module (ECM) with a signal that indicates camshaft position and engine speed.

The CMP sensor signal is used by the ECM to synchronize piston position to injector firing sequence. The injector firing order sequence begins when the ECM detects the narrow vane on the timing disk indicating #1 cylinder. Engine position for each cylinder is then continuously calculated as each vane on the timing disk passes by the CMP sensor. This information is processed by the ECM and used for injection timing and fuel delivery control. The ECM can then initiate the beginning of firing.

OPERATION

The Camshaft Position Sensor is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through the magnetic field. The frequency of the windows passing by the sensor as well as the width of selected windows allows the ECM to detect engine speed and position. When the narrow vane passes the CMP sensor the signal on time is less than when the other vanes pass the sensor. This produces a signal that the ECM uses to indicate engine position.

Engine speed is detected by the ECM by counting the frequency of the 24 signal pulses for each camshaft revolution.

ECM DIAGNOSTICS

Once the ECM has recognized the narrow vane (wide window) it will synchronize the engine firing order to the timing of the CMP signal. Every 2 crankshaft revolutions it will verify that synchronization. If the ECM receives too many or too few pulses for the number of engine revolutions, it will set a fault code.

The engine will not operate without a functioning CMP signal. However, the ECM will attempt to determine the cause of an invalid signal and identify it with a fault code.

CMP codes that are set will become inactive codes if the key is turned off. These codes can be retrieved using the Audio Test switch to initiate a Self Test Input (STI) diagnostic test (at instrument panel) or the Electronic Service Tool.

Flash Code *143*

ATA CODE SID 21 FMI 2

Wrong Number Of CMP Signal Transitions Per Cam Revolution

Code 143 indicates the ECM has received CMP signals with the wrong number of transitions. This indicates that the ECM has counted the voltage transitions and found less than the specified number of pulses from the sensor. When this problem is continuous, the engine will stop running and the ECM will log an active code. If the key is shut off, the code will become an inactive code. This code will not turn the warning light on.

Possible causes include:

- Intermittent CMP signal caused by an intermittent circuit.
- Defective Camshaft Position Sensor, or incorrect CMP sensor to timing disk clearance.

CMP - Camshaft Position Sensor (Continued)

CAMSHAFT POSITION SENSOR (CMP) EXTENDED SYSTEM DESCRIPTION (CONTINUED)

FLASH CODE *144*

ATA CODE SID 21 FMI 2

CMP Signal Noise Detected

Code 144 indicates that the ECM has detected voltage spikes or transitions other than the CMP signal. If this problem is continuous the engine could stop running and the ECM will log an active code. If the key is shut OFF, the code will become an inactive code. This code will not cause the warning light to illuminate.

Possible causes include:

- Poor ground connections for CMP or other electronic components.
- Wire harness shielding missing or incorrectly installed on the engine harness.
- Outside components that could induce voltage signals.

FLASH CODE *145*

ATA CODE SID 21 FMI 12

CMP Signal Inactive While ICP Has Increased

Flash code 145 indicates that the ECM does not detect a CMP signal. This code would be set if the engine was rotating and the ECM detected a rise in ICP pressure, but did not detect a CMP signal. To set this code the engine must be rotated long enough for the ICP to increase. When this code is set the engine will not operate. This code will not cause the warning light to illuminate.

Possible causes include:

- Defective CMP sensor, faulty sensor circuitry.
- Incorrect air gap between sensor and camshaft timing disk.

FLASH CODE *612*

ATA CODE SID 21 FMI 7

Incorrect ECM Installed For CMP Timing Disk

Flash code 612 indicates that the ECM has monitored the CMP signal and the signal is incorrect for the programming in the ECM. This means that the ECM does not recognize the signal generated from the timing disk and CMP sensor.

Possible causes include:

- ECM has been accidently replaced with an incorrect ECM for the particular engine application.
- Incorrect signal due to a defective CMP sensor.
- Incorrect air gap between the CMP sensor and the timing disk.

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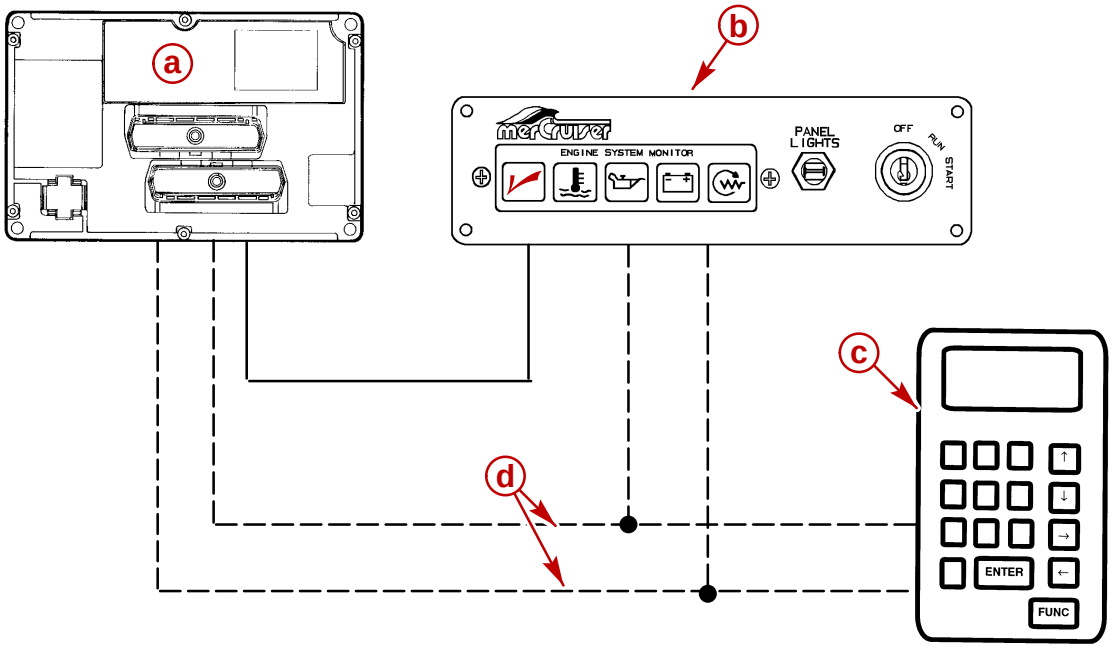
ATA Communications



a - ECM
b - Engine System Monitor Panel and Harness
c - Electronic Service Tool (EST)
d - ATA Communications / Diagnostic / Program Link

SIGNAL FUNCTIONS

Data Communication Link - the Data Communication Link signal is a 0 to 5 volt variable width wave form signal that enables communication between the Electronic Service Tool (EST) and the ECM. It is used for communication of diagnostic and calibration data.

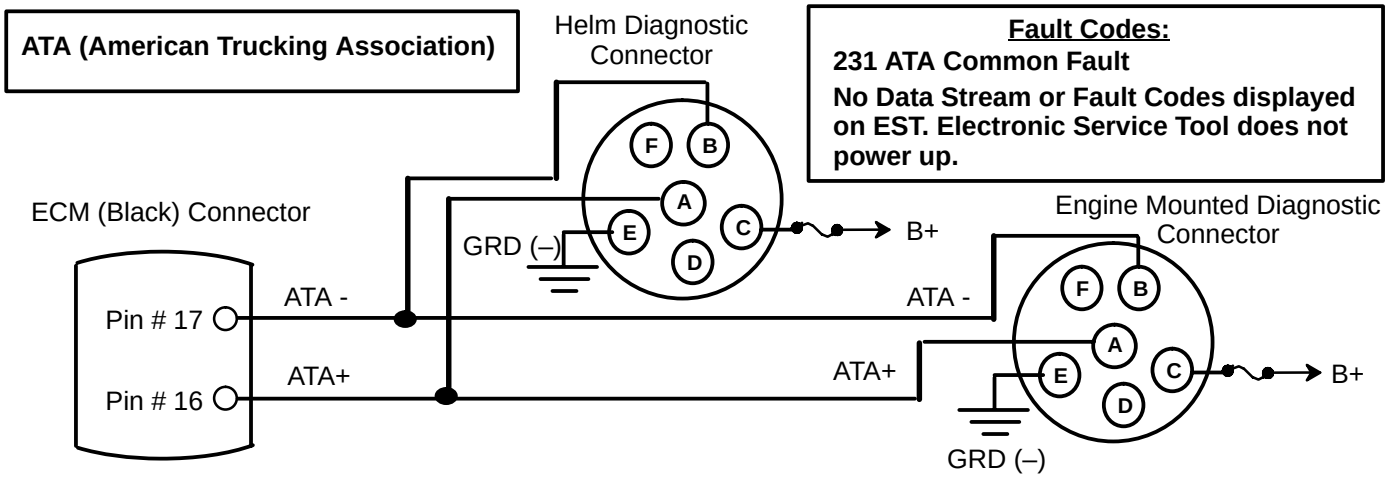
ATA Diagnostic / Programming Link - The ATA signal is a 0 to 5 volt width wave form signal that enables communication between the ECM and the (EST). It is used for communication of calibration, programming and diagnostic information.

Helm Dash Board Information - Information from the ECM is used to operate the Check Engine Lamp on the Engine System Monitor Panel to display operational and diagnostic information.

FAULT DETECTION / MANAGEMENT

The ECM can detect on a continuous basis an open, short or intermittent connection on the DCL and ATA lines.

ATA Communications (Continued)



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Key ON Engine OFF – Voltage Checks at EST Connector

(Check with breakout box installed and the Ignition Key in RUN (ON) position, engine OFF)

+ Test Points	Spec.	Signal	Comments
C to E	B+	Power	Should be power at C at all times. If no power, check ground and power circuits

EST & Helm Diagnostic Connector Checks to Ground

(Check with Helm connector unplugged, Positive Battery Cable Disconnected and Ignition key OFF)

Test Points	Spec.	Signal	Comments
EST			
A to Grd.	> 1000 ohms	ATA +	Less than 1000 ohms indicates a short to grd. either thru the harness or internal in the
B to Grd.	> 1000 ohms	ATA –	ECM. Disconnect ECM & measure to grd. again. If short still present, repair harness.
C to Grd.	> 1000 ohms	PWR	With Fuse F11 removed, a reading less than 1000 ohms indicates a short to ground.
E to Grd.	< 5 ohms	GRD	More than 5 ohms indicates an open circuit and will cause the EST tool not to power up.
Helm Connector			
A to Grd.	> 1000 ohms	ATA +	Less than 1000 ohms indicates a short to grd. either through the harness or internal in the
B to Grd.	> 1000 ohms	ATA –	ECM. Disconnect ECM & measure to grd. again. If short still present, repair harness.

EST & Helm Diagnostic Connector Resistance Checks

(Check with breakout box installed and Ignition Key OFF)

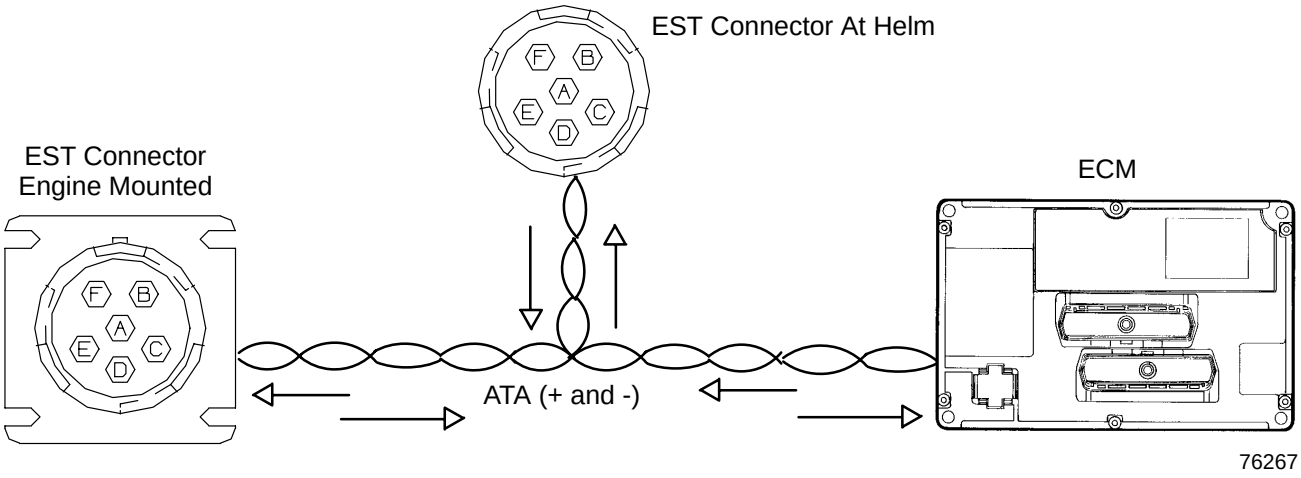
Test Points	Spec.	Signal	Comments
EST Connector			
A to #16	< 5 ohms	ATA+	Resistance from ECM connector to EST connector
B to #17	< 5 ohms	ATA–	Resistance from ECM connector to EST connector
C to C2	< 5 ohms	PWR	Resistance from EST connector to Connector 2 at (power) fuse holder
E to Grd.	< 5 ohms	GRD	greater than 5 ohms indicates an open circuit and will cause the EST tool not to power up
Instrument Cluster Connector			
A to #16	< 5 ohms	ATA +	Resistance from ECM to Dash connector
B to #17	< 5 ohms	ATA –	Resistance from ECM chassis connector (black) to Dash (green) connector

Fault Code Descriptions

231 = ATA Common Fault – ATA wiring or connector faults, interference on data bus (e.g. dash or WTEC controller), faulty ECM

- No Data Stream or Fault Codes displayed on Electronic Service Tool or Electronic Service Tool will not power up
- Dash display for speedymeter, tach, oil pressure, coolant temperature and battery voltage does not function

ATA Communications (Continued)



EXTENDED DESCRIPTION - ATA COMMUNICATION

The engine control system “communicates” with the Electronic Service Tool through EST connectors as shown. The EST communicates with the ECM using the American Trucking Association (ATA) data link lines.

The ATA circuits use twisted wire pairs. All repairs to these pairs must maintain one complete twist per inch along the entire length of the circuits. These circuits are polarized (one positive and one negative) and reversing the polarity of these circuits will disrupt communications.

NOTE: *The ATA data link is defined by SAE recommended practices J1708 and J1587. This link and EST connector were adopted by the Recommended Practices 1201 and 1202.*

ATA DATA LINK CONNECTOR

All communications between the EST and the engine control systems, is done through the EST connectors. This communications link supports:

- Displaying fault codes and operating conditions on the EST.
- Performing proprietary diagnostic tests programmed into the cartridge.
- Clearing fault codes.
- Programming performance parameter values.

The EST connector has six pins, labeled A through F, that provide the following:

a. Fused BATTERY power is provided to connector terminal “C” to provide battery power for electronic service tools. Pin “E” provides a battery ground for the EST.

b. Connector terminal “A” is connected to ECM terminal 16. Terminal “B” is connected to ECM terminal 17. These two terminals are provided for communication to the service tool.

ATA Communications (Continued)

POSITIVE AND NEGATIVE ATA DATA LINKS

The RED Positive and BLUE Negative Data Link Busses connect the EST connector (384) to the ECM. They are also the connection point for other electronic components that require access to the engine control system through the ATA communications link.

EST CONNECTOR

The engine control system does not detect faults in the power or ground circuits to EST connector (384). If the service tool does not power up when connected, try the service tool on another engine if one is available to determine if the service tool is working properly. If the service tool is OK, then check power and ground circuits at the ATA connection.

EST DISPLAYS

Should the EST display NO DATA, the ATA data link circuit from the EST connector to the ECM may be disrupted. Verify that the key is ON and then perform diagnostic steps

ECM DIAGNOSTICS

Flash codes that can be caused by defects occurring in the ATA circuits are discussed in this section. There are also Flash Codes related to or caused by faulty communication (corrupt or invalid data transmitted by the ECM), that are discussed in this section.

FAULT CODES

FLASH CODE *231*

ATA CODE SID 250 FMI 2

ECM: *ATA COMMON FAULT*

Code 231 **does not** turn Check Engine Lamp ON. This code can occur when the ECM can't access the ATA data link. If this occurs, there will not be any ATA data available with the electronic service tool (EST). The fault code may be "flashed" using the Audio Test switch, located on the instrument panel, to initiate an STI Diagnostic Test.

Possible **wiring causes** include:

- ATA positive or negative circuits between EST and ECM and any other electronic devices using the ATA bus: shorted (high or low), open, or busy (too many devices).

If code 231 is Active:

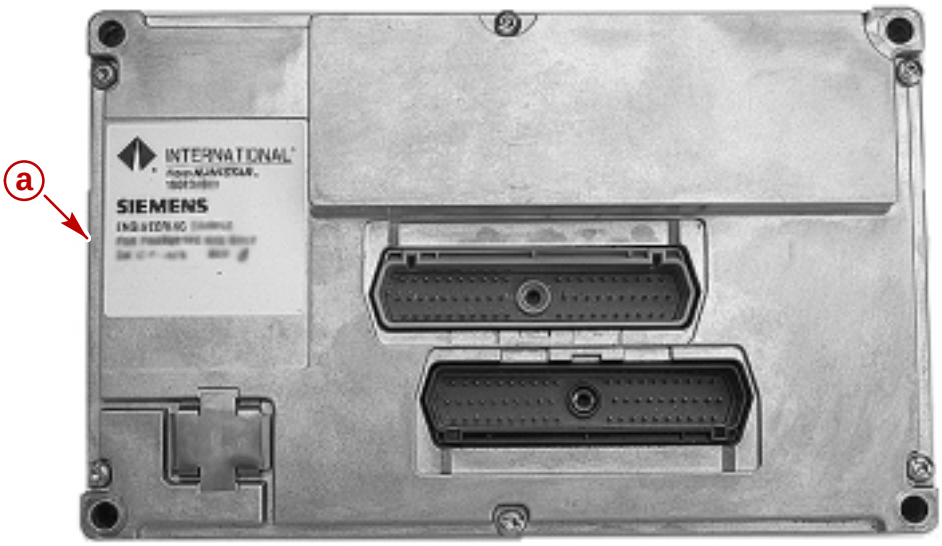
1. Perform Testing the ATA Data Link Circuits.
   a. If defect is found in ATA circuits, correct defect.
   b. If defect is not found in ATA circuits, investigate **system causes**.

Possible **system causes** include:

- A defective ATA device connected to the ATA bus is pulling the signal to ground. (ATA devices not currently present on marine applications.)

If no system causes are present, replace the ECM.

ECM - Electronic Control Module Self-Diagnostics



EG–6392

a - ECM

SIGNAL FUNCTION

The Electronic Control Module (ECM) monitors and controls engine operation and performance, communicates engine and vessel operational information to the helm and runs diagnostic/programming tools.

FAULT DETECTION / MANAGEMENT

During normal operation, the ECM automatically performs diagnostic checks upon itself and the total electronic control system. The ECM self tests include memory checks, programming checks as well as internal power supply checks for power to the injectors. The ECM is capable of internal fault detection and dependent upon the severity of the problem, can provide fault management strategies to allow limited engine/vessel operation.

ECM - Electronic Control Module Self-Diagnostics (Continued)

NORMAL OPERATION DIAGNOSTICS

During normal engine operation, the ECM automatically performs several tests to detect faults.

CONTINUOUS DIAGNOSTICS

Continuous diagnostic checks are made by the ECM during vehicle operation to detect out-of-range, rationality and system faults. Flash codes 112 and 113 can be set during this diagnostic process. Refer to (ECM PWR) in this section.

ON DEMAND DIAGNOSTICS (SERVICE DIAGNOSTICS)

The ECM will perform On-Demand Diagnostics (Service diagnostics) when requested by the service technician. The KOEO Standard Test Procedure includes:

- ECM Internal Self-Tests.
- Output Circuit Checks (OCC).

ECM INTERNAL SELF-TESTS

Use the Prolink EST to perform the self-tests. The test procedure checks the ECM's CPU, RAM, and ROM. The test may set the following flash codes.

FLASH CODE 111 -

No Fault Conditions Detected

ATA CODE:	None
Condition Description:	No Fault Conditions Detected
Note:	Can only determine if ECM has detected continuous faults or faults detected during an Output Circuit Check, faults generated during an On–Demand Test such as Cylinder Contribution Tests can only be accessed by an Electronic Service Tool.

FLASH CODE 525 -

Injector Drive Diagnostics

ATA CODE:	SID 254 FMI 6
Condition Description:	Injector Driver Circuit Fault
Symptoms:	Possible hard start/no start or low power condition
Possible Causes:	Shorted engine harness, injector harness or defective ECM
Actions:	Perform injector harness checks in Injector Circuit Diagnostics. If no defects found replace ECM and retest

ECM - Electronic Control Module Self-Diagnostics (Continued)

FLASH CODE 614 -

ECM Memory/Programming Diagnostics

ATA CODE:	SID 252 FMI 13
Condition Description:	EFRC/EECM ING Configuration Mismatch
Symptoms:	Possible hard start / no start or low power condition.
Possible Causes:	Wrong EFRC (Engine Family Rating Code) selected for the ECM strategy programmed in the module.
Actions:	Check EFRC and verify if it matches ECM strategy level. Reprogram ECM or change EFRC as necessary.

FLASH CODE 621

ATA CODE:	SID 253 FMI 1
Condition Description:	Manufacturing Defaults Selected
Symptoms:	Very low power (25HP).
Possible Causes:	Programmable parameters for ECM never programmed in module. (Most likely to occur with new engine or new module).
Actions:	Program programmable parameters.

FLASH CODE 622

ATA CODE:	SID 253 FMI 0
Condition Description:	Engine using Field Default Rating
Symptoms:	Low power (lowest rating in engine class) and engine features not working.
Possible Causes:	Programmable parameters for ECM module incorrectly programmed in module.
Actions:	Program programmable parameters.

FLASH CODE 623

ATA CODE:	SID 253 FMI 13
Condition Description:	Invalid Engine Family Rating Code (EFRC)
Possible Causes:	Wrong EFRC (Engine Family Rating Code) selected for the ECM strategy programmed in the module.
Symptoms:	Possible hard start / no start or low power condition.
Actions:	Check EFRC and verify if it matches ECM strategy level. Reprogram ECM or change EFRC as necessary.

FLASH CODE 624

ATA CODE:	SID 240 FMI 14
Condition Description:	Field Defaults Active
Symptoms:	Low power (lowest rating in engine class) and vessel features not functioning.
Possible Causes:	Programmable parameters for ECM module incorrectly programmed in module.
Actions:	Program programmable parameters.

ECM - Electronic Control Module Self-Diagnostics (Continued)

FLASH CODE 631

ATA CODE:	SID 240 FMI 2
Condition Description:	Read Only Memory (ROM) Self Test Fault
Symptoms:	No Start.
Possible Causes:	Internal ECM problem.
Actions:	Replace ECM.

FLASH CODE 632

ATA CODE:	SID 254 FMI 12
Condition Description:	RAM Memory–CPU Self Test Fault
Symptoms:	No Start.
Possible Causes:	Internal ECM problem.
Actions:	Replace ECM.

FLASH CODE 655

ATA CODE:	SID 240 FMI 13
Condition Description:	Programmable Parameter List Level Incompatible
Possible Causes:	No start or run in field defaults.
Symptoms:	Programming problem or internal ECM problem.
Actions:	Attempt to program ECM, if no help replace ECM.

FLASH CODE 661

ATA CODE:	SID 240 FMI 11
Condition Description:	RAM Programmable Parameter List Corrupt
Symptoms:	No start or run in field defaults.
Possible Causes:	Internal ECM problem.
Actions:	Replace ECM.

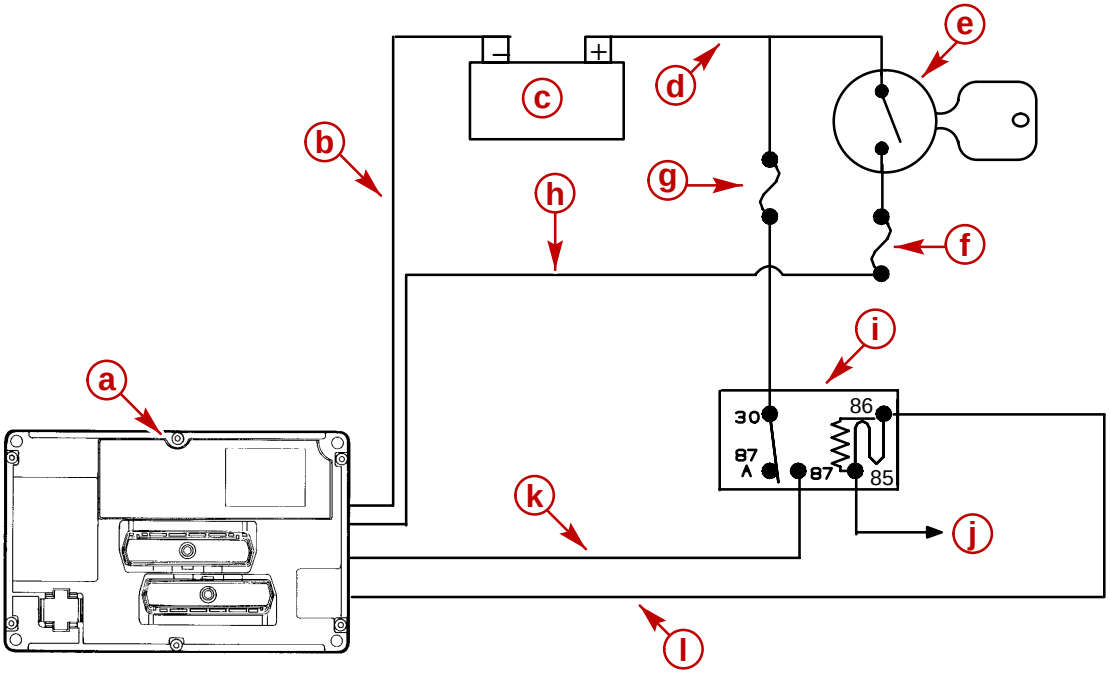
FLASH CODE 664

ATA CODE:	SID 253 FMI 14
Condition Description:	Calibration Level Incompatible
Symptoms:	No start or run in field defaults.
Possible Causes:	Programming problem or internal ECM problem.
Actions:	Attempt to program ECM, if no help replace ECM.

FLASH CODE 665

ATA CODE:	SID 252 FMI 14
Condition Description:	Programmable Parameter Memory Content Corrupt
Symptoms:	No start or run in field defaults.
Possible Causes:	Internal ECM problem.
Actions:	Replace ECM.

ECM - Electronic Control Module Power Supply



EG–1226

ECM Power Supply Circuit Diagram

- **a** - ECM
- **b** - Ground
- **c** - Battery
- **d** - Battery +
- **e** - Key Switch
- **f** - Fuse
- **g** - Circuit Breaker
- **h** - Key Switched Battery Voltage
- **i** - ECM Relay
- **j** - V BATT
- **k** - Relay Switched Battery Power
- **l** - ECM Controlled Ground for Relay

CIRCUIT FUNCTIONS

The Electronic Control Module requires a 12 volt source of power in order to perform its functions. It receives this operating power directly from the vessels batteries via the ECM relay contacts each time the ignition key switch is turned to the RUN (ON) position. Turning the ignition key switch to RUN causes the ECM to provide an internal ground to the coil side of the ECM relay. This causes the relay to close its contacts and provide the ECM with the power necessary to perform its various functions.

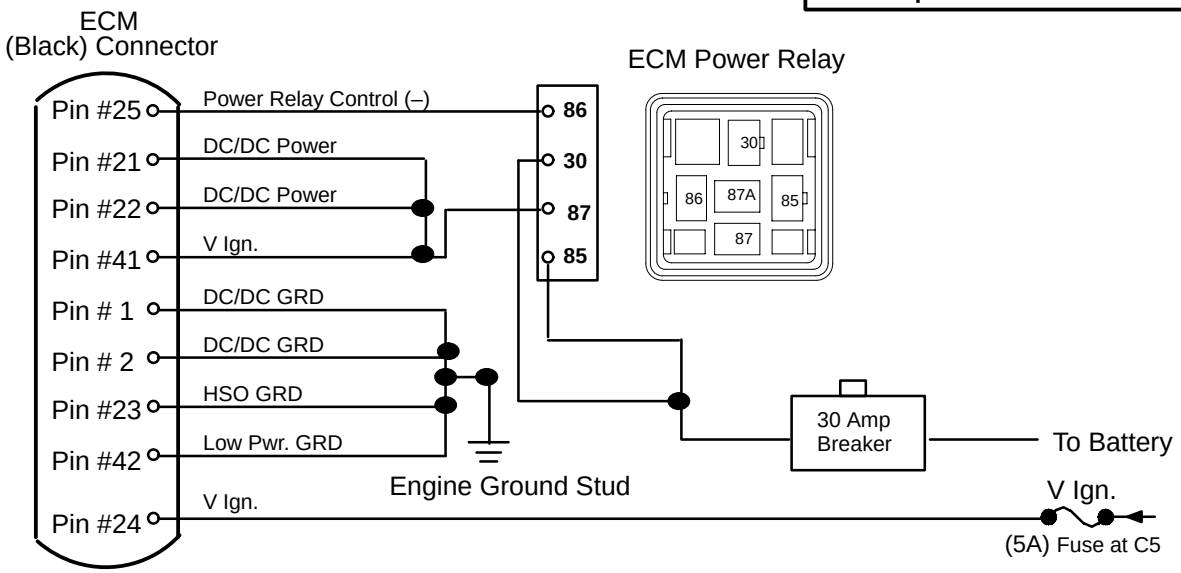
FAULT DETECTION MANAGEMENT

The ECM internally monitors battery voltage. If the ECM continuously receives less than 6.5 volts or more than 18 volts a fault code will be set. The fault code will not cause the Check Engine lamp to be turned ON. If the condition is intermittent, the code will be logged as an inactive code. The ECM will not operate at voltages continuously below 6.5 or above 18 volts.

ECM - Electronic Control Module Power Supply (Continued)

ECM Power / Power Relay (ECM–PWR)

Fault Codes:
112 Internal power supply out of range high
113 Internal power supply out of range low
626 Unexpected Reset Fault



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Key in RUN (ON) Engine OFF– Voltage Checks at ECM Power Relay Socket
(Check with ECM Relay Removed and the Ignition Key in RUN (ON) Engine OFF.)

+Test Points	Spec.	Comments
85 to grd.	12v ± 1.5v	Voltage present at all times. If no voltage, check ground and power circuits from vessel connections
30 to grd.	12v ± 1.5v	Voltage present at all times. If no voltage, check ground and power circuits to battery CKTs.
86 to grd.	.6 to 2v	ECM grounds relay through internal transistor. Expect 1.2v with Key in RUN (ON) position, relay removed.
87 to grd.	0v	No voltage present when relay is removed

(Check with breakout box installed, ECM power relay installed and Ignition Key in RUN (ON) position.

+Test Points	Spec.	Comments
24 to grd.	12v ± 1.5v	Power from ignition switch to ECM
21 to grd.	12v ± 1.5v	Power from relay to ECM
22 to grd.	12v ± 1.5v	Power from relay to ECM
41 to grd.	12v ± 1.5v	Power from relay to ECM
25 to grd.	.6v to 2v	ECM grounds relay through internal transistor. Expect 1.2v with Key ON.
1 to grd.	0v	Ground – voltage reading indicates poor ground to battery
2 to grd.	0v	Ground – voltage reading indicates poor ground to battery
23 to grd.	0v	Ground – voltage reading indicates poor ground to battery
42 to grd.	0v	Ground – voltage reading indicates poor ground to battery

Circuit Resistance Checks
(Check with breakout box installed, ECM power relay installed and Ignition Key OFF.

+Test Points	Spec.	Comments
1,2,23,42 to Grd.	< 5 ohms	Resistance from ECM grounds to battery grounds
Breaker to 25	60–120 ohms	Measure resistance across relay coil – Open Breaker to test
30 to B+	< 5 ohms	Power from relay to ECM (Remove relay to test & test at location 30 in relay socket.)

Fault Code Descriptions

112 = Internal ECM voltage was detected above 18 volts.
113 = Internal ECM voltage was detected below 6.5 volts.
626 = ECM detected intermittent power loss through ECM relay

ECM - Electronic Control Module Power Supply (Continued)

EXTENDED DESCRIPTION

Refer to the ECM Power Supply Circuit Diagram and Terminals / Connectors in SECTION 4E, for the following discussion.

The Electronic Control Module (ECM) receives its power directly from the vessel batteries when the ECM power relay is energized. This allows maximum power transfer from the batteries to the ECM with a minimum amount of power loss. The wire harness which supplies ECM power contains a 30 Amp circuit breaker to protect it from short circuits.

When the key switch is turned ON, ignition power from fuse at C5 connector (5 A) is supplied to pin number 24 of the ECM. This indicates to the ECM that the ignition switch is ON and it is time to enable the ECM power relay.

Power to the ECM Power Relay control coil (terminal 85) is provided by the 30 Amp circuit breaker. The ECM will enable the ECM power relay by completing the ground circuit (internally) to the relay at ECM pin 25.

When the ECM Power Relay is enabled power at terminal 30 from the vessel batteries is switched directly to the ECM from terminal 87 of the relay to pins 21, 22 and 41 of the ECM. The vessel battery power for this relay to switch is supplied directly from the battery through the 30 Amp breaker and to terminal 30 of the relay.

ECM DIAGNOSTICS

If the ECM detects more than 18 volts at pins 21, 22 and 41 it will set flash code 112. A voltage of less than 6.5 volts detected by the ECM will set flash code 113. The ECM is capable of detecting an intermittent interruption of power or ground circuits. Flash code 626 will be set indicating an unexpected reset has occurred.

FLASH CODE *112*

ATA CODE PID 168 FMI 3

ECM: *Internal Voltage Power Out Of Range High*

Possible causes include:

- Vehicle voltage supply to the ECM is continuously more than 18 volts. Excessive voltage can be caused by a defective alternator.
- Additional voltage provided while attempting to jump start engine or improper external battery connections that could cause the additional voltage increase.
- The ECM has an internal fault.

If the condition causing code 112 is intermittent, the code will change from active to inactive status. Code 112 does not cause the Check Engine Lamp to turn ON.

ECM - Electronic Control Module Power Supply (Continued)

FLASH CODE *113*

ATA CODE PID 168 FMI 4

ECM: *INTERNAL VOLTAGE POWER OUT OF RANGE LOW*

Code 113 can be caused by consistently less than 6.5 volts being applied to ECM terminals 37 and 57. Code 113 does not turn the Check Engine Lamp ON. If the condition causing Code 113 to set is an intermittent condition, when the condition is no longer present, the code status will change from active to inactive.

Possible causes include:

- A defective alternator.
- Low batteries.
- And/or increased resistance in the battery feed circuits.

FLASH CODE *626*

ATA CODE PID 254 FMI 56

ECM: *UNEXPECTED RESET FAULT*

Any time power is interrupted to the ECM due to intermittent power feed circuits caused by loose or dirty connections at the batteries or at ground cables, the ECM may “power down”. When the power or ground circuit becomes intact again the ECM will “reboot” itself. This may cause erratic engine operation. Flash code 626 will be set anytime flow of power is interrupted to the ECM. Turning the ignition key OFF and then to RUN again causes the code to change from an active to an inactive code status. Code 626 will not cause the Check Engine lamp to illuminate.

TROUBLESHOOTING

If Flash Code 112 is active, refer to appropriate Service Manual SECTIONS and troubleshoot the charging system.

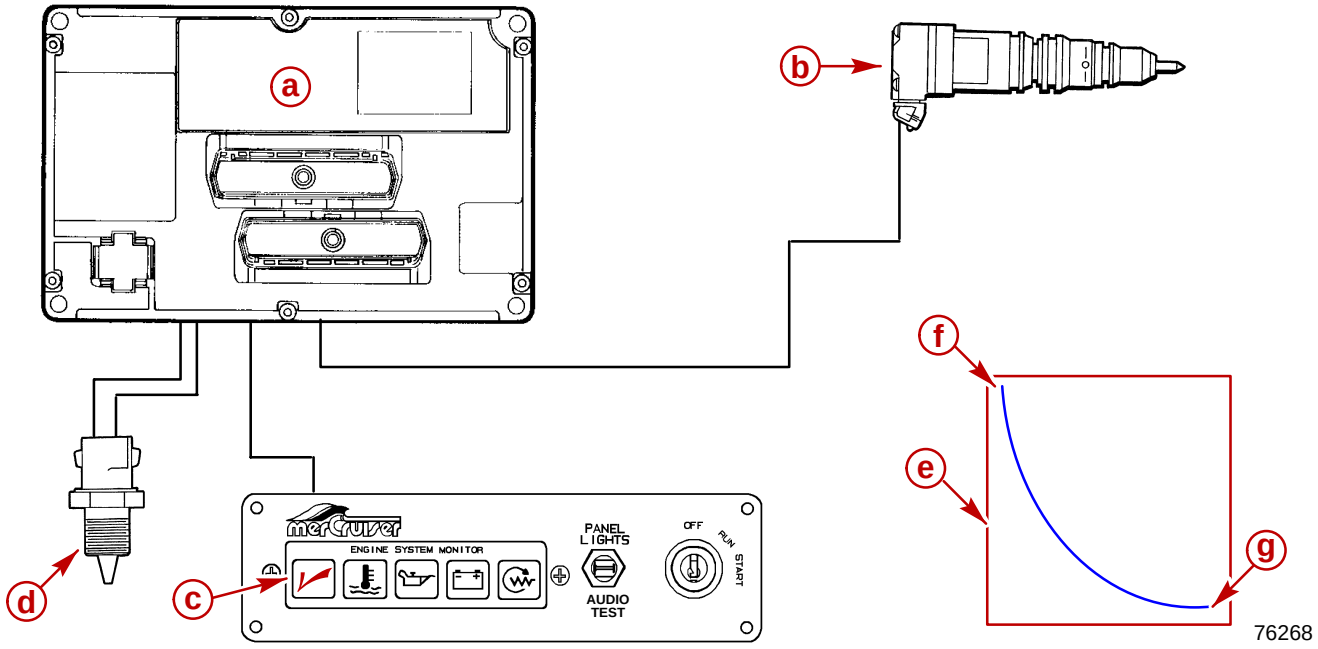
If Flash Code 113 is active or NO voltage is present to the ECM, perform TESTING ECM POWER SUPPLY CIRCUITS. If the power supply to the ECM checks good, replace the ECM.

If a no-start condition is present and there is no power to the ECM, perform TESTING ECM POWER SUPPLY CIRCUITS.

BEFORE PERFORMING ANY TESTS

Inspect ECM power relay circuit connectors for pushed back, damaged, corroded or dirty terminals as well as making sure the terminals and wires are properly crimped. Make sure connectors are properly joined together. Also check for damaged wiring and clean, tight battery and ground connections.

ECT - Engine Coolant Temperature Sensor



a - ECM
b - Fuel Quantity and Timing Control (Injectors)
c - Check Engine Lamp
d - ECT Sensor
e - ECT Signal (Analog Voltage) Graph
f - 5 Volts (Colder)
g - 0 Volts (Warmer)

SIGNAL FUNCTION

The Engine Coolant Temperature (ECT) sensor is a thermistor type sensor that has a variable resistance that changes when exposed to different temperatures. When interfaced with the ECM it produces a 0 to 5 volt analog signal that will measure temperature.

Coolant Temperature Compensation - At coolant temperatures greater than 214° F (101° C) fuel quantity is reduced by 6% for each degree of temperature (°C), until engine temperature reaches 218° F (103° C). Above 218° F (103° C) fuel is reduced by 3% for each °C increase in temperature.

Idle Speed - At temperatures below 158° F, (70° C) low idle is incrementally increased to a maximum of 875 RPM.

Glow Plug Control - Glow plug relay and lamp on times are directly affected by engine coolant temperature.

Engine Warning and Protection - Optional feature when enabled, will warn driver of overheat condition and can be programmed to shut the engine down.

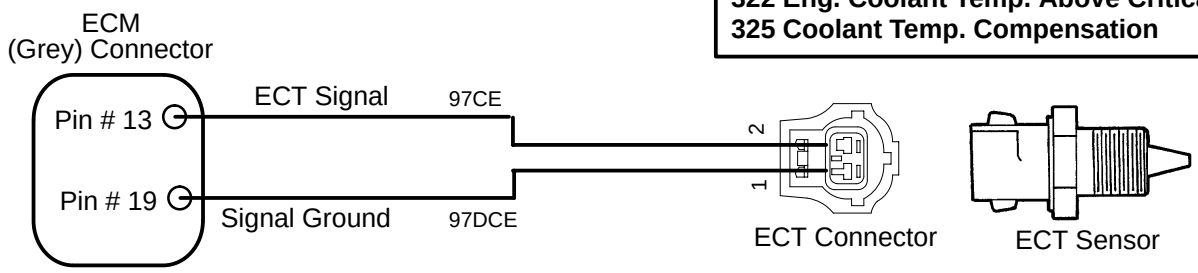
FAULT DETECTION / MANAGEMENT

An ECT signal that is detected out of range high or low by the ECM will cause the ECM to ignore the ECT signal and assume an engine coolant temperature of -29° F (-20° C) for starting and a temperature of 180° F (82° C) for engine running conditions. The Check Engine lamp will also be illuminated as long as the fault condition exists.

ECT - Engine Coolant Temperature Sensor (Continued)

Engine Coolant Temperature Sensor (ECT)

Fault Codes:
114 Out of Range Low
115 Out of Range High
316 Eng. Coolant Temp. unable to reach commanded setpoint
321 Eng. Coolant Temp. Above Warn
322 Eng. Coolant Temp. Above Critical
325 Coolant Temp. Compensation



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks
(Check with sensor connector disconnected and Ignition Key ON)

Test Points	Spec.	Comments
2 to Grd.	4.6 – 5.0 v	Pull up voltage, if no or low voltage circuit has open or high resistance or short to grd.
1 to Grd.	0 – .25 v	If greater than .25 volts, wire is shorted to V Ref. or battery.

Connector Checks to Vessel Ground
(Check with sensor connector disconnected, positive battery cable disconnected and Ignition Key OFF)

Test Points	Spec.	Comments
1 to Grd.	< 5 ohms	Resistance to chassis ground, check with key off, > than 5 ohms the harness is open.
2 to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#19 to 1	< 5 ohms	Resistance from harness connector to 60 pin connector – Signal ground
#13 to 2	< 5 ohms	Resistance from harness connector to 60 pin connector – ECT signal

Test Points (+) #13 to (–) #19		**Operational Signal Checks (Check with breakout box installed on ECM and Gray engine harness)**		
Voltage	Temp. ° F	Temp. ° C	Resistance	Comments
0.356v	230	110	1.19 K ohms	
0.552v	209	99	2 K ohms	
.648	199	93	3.84 K ohms	
3.87v	32	0	69.2 K ohms	
4.33v	–5	–20	131 K ohms	

Fault Code Descriptions

Circuit Faults:
114 = Signal was less than .127 volts for more than 0.1 seconds. (Probable short to ground.)
115 = Signal voltage was greater than 4.6 volts for more than 0.1 seconds. (Probable open circuit)
Cooling System Faults:
316 = Engine temp. has not warmed above specification after 120 min. of operation. (Only on engines with cold ambient protection turned on.)
321 = Engine Coolant Temperature above WARN level 228° F (109° C)
322 = Engine Coolant Temperature above Critical level 234° F (112.5° C)
325 = Coolant Temperature Compensation enabled. (Reduces fuel quantity 6 % for each degree°C above 225° F (107° C)

ECT - Engine Coolant Temperature Sensor (Continued)

FUNCTION

The engine control system includes an Engine Coolant Temperature sensor. The ECM measures the Engine Coolant Temperature signal and uses this information for Coolant Temperature Compensation and optional high temperature warning.

Coolant temperature compensation is used to protect the engine if the coolant temperature is too high. The ECM monitors the ECT signal to determine the coolant temperature. If the coolant reaches 214° F (101° C), the ECM will reduce the fuel delivery by 6% for each Celsius degree of temperature increase. If the coolant temperature increases to 218° F (104° C), fuel quantity will be reduced 3% for each Celsius degree of temperature increase. Coolant Temperature Compensation can be programmed to be inoperative in certain applications where full engine performance is required over the protection of the engine.

On engines equipped with an engine warning system, the ECM will activate the audible warning alarm and illuminate the Coolant Temperature warning light when the engine coolant temperature reaches 225° F (107° C).

OPERATION

The Engine Coolant Temperature Sensor is a thermistor type sensor which changes resistance when exposed to different temperatures.

When the temperature of the coolant is decreased, the resistance of the thermistor increases which causes the signal voltage to increase. As the temperature of the coolant is increased the resistance of the thermistor decreases, which causes the signal voltage to decrease.

The ECT sensor is supplied a regulated 5 volt reference voltage to connector terminal 2, from ECM terminal 13. The sensor is grounded at connector terminal 1 through the signal return, terminal 19 at the ECM. As the coolant temperature increases or decreases, the sensor changes resistance and provides the ECM with the coolant temperature signal voltage at terminal 13 of the ECM. This signal voltage is then read by the ECM to determine the temperature of the coolant.

ECM DIAGNOSTICS

With the ignition key ON, the ECM continuously monitors the ECT circuit for expected voltages. If the signal voltage is less than or more than expected the ECM will set a fault code.

If the ECM detects a fault in the ECT signal, the ECM will disregard the signal and default to a temperature of 180°F (82° C) for engine running operation and -4° F (-20° C) for starting the engine. If the fault is no longer present, the ECM will once again return to normal operation using the ECT signal for processing.

Faults in the ECT signal can be retrieved using the Audio Test switch to initiate a Self Test Input test (STI) or the Electronic Service Tool. If the fault is no longer present, it will be stored as an Inactive Code.

FLASH CODE *114*

ATA CODE PID 110 FMI 4

ECT: *Out Of Range Low*

An out of range low code will be set if the ECM detects a voltage less than .127 volts for more than 0.1 seconds. If this fault is Active, the ECM will use the default value of 180° F (82° C).

Possible causes include:

- A short to ground or a shorted or biased sensor

ECT - Engine Coolant Temperature Sensor (Continued)

FLASH CODE *115*

ATA CODE PID 110 FMI 3

ECT: *Out Of Range High*

An out of range high code will be set if the ECM detects a voltage greater than 4.6 volts for more than 0.1 seconds. If this fault is Active, the ECM will use the a default value of 180° F (82° C).

Possible causes include:

- An open circuit.
- An open sensor.
- A short to another voltage source.

FLASH CODE *321*

ATA CODE PID 110 FMI 0

Engine Coolant Temperature Above Warning Level

Code 321 will be set if the ECM detects engine coolant temperature above 225° F (107° C). When this occurs, the ECM illuminates the COOLANT TEMPERATURE warning light and sounds the audible alarm (if equipped), alerting the operator that a potential for engine damage exists.

If the temperature drops below 225° F (107° C), the code will become inactive and the ECM will return to normal operation.

FLASH CODE *322*

ATA CODE PID 110 FMI 7

Engine Coolant Temperature Above Critical Level

Code 322 will be set if the ECM detects engine coolant temperature above 235° F (112.5° C). When this occurs, the Coolant Temperature lamp illuminates and the audible alarm sounds (if equipped). This will alert the operator that the temperature is increasing (having set code 321) indicating a potential for engine damage. With code 322 active, the engine will shut down. At the same time the code and current engine hours will be recorded in the ECM as an Engine Event.

If the temperature drops below 235° F (112.5° C), the code will become inactive and the ECM will return to normal operation. Should the engine shut down, it can be restarted and operated for an additional 30 seconds to move the vessel.

FLASH CODE *325*

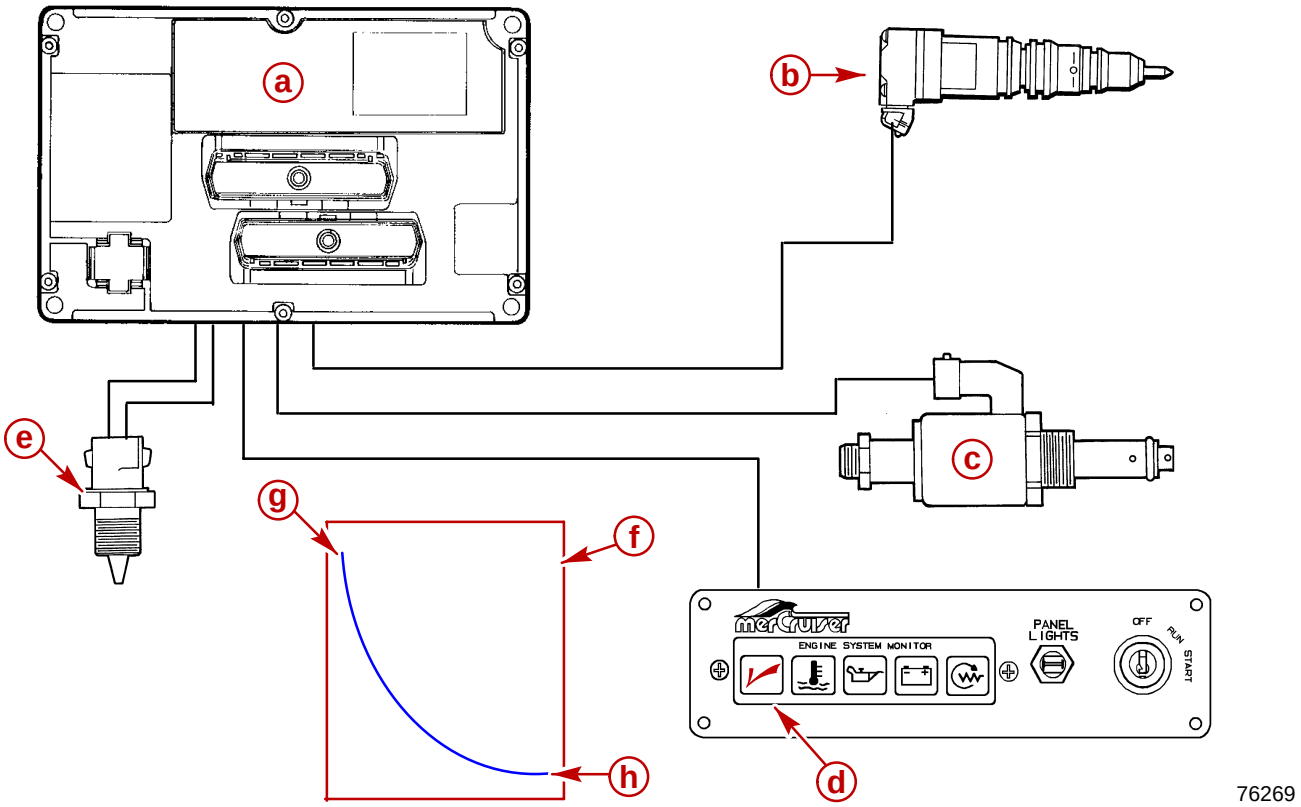
ATA CODE PID 110 FMI 14

Power Reduced, Matched To Cooling System Performance

Code 325 will be set if the cooling system temperature exceeds 214° F (101° C). At this temperature the ECM will reduce the fuel delivered to the engine at or near the maximum demand level. For each one Celsius degree of temperature the fuel will be reduced 6%. This reduces the heat produced by the engine thereby reducing the burden on the engine cooling system.

As the temperature is reduced the compensation level is reduced until the temperature drops below 214° F (101° C) at which normal operation is resumed.

EOT - Engine Oil Temperature Sensor



a - ECM
b - Fuel Quantity and Timing Control (Injectors)
c - Injection Control Pressure Regulator
d - Check Engine Lamp
e - EOT Sensor
f - EOT Signal (Analog Voltage) Chart
g - 5 Volts (Colder)
h - 0 Volts (Warmer)

SIGNAL FUNCTIONS

The Engine Oil Temperature (EOT) sensor is a thermistor type sensor that has a variable resistance which changes when exposed to different temperatures. When interfaced with the ECM, it produces a 0 to 5 volt analog signal that indicates temperature.

Cranking Fuel Quantity / Timing Control – The EOT signal is used to determine the timing and quantity of fuel required to optimize starting over all temperature conditions.

Temperature Compensation – Fuel quantity and timing is controlled throughout the total operating range to compensate for oil viscosity changes due to temperature variations and insure that adequate torque and power is available.

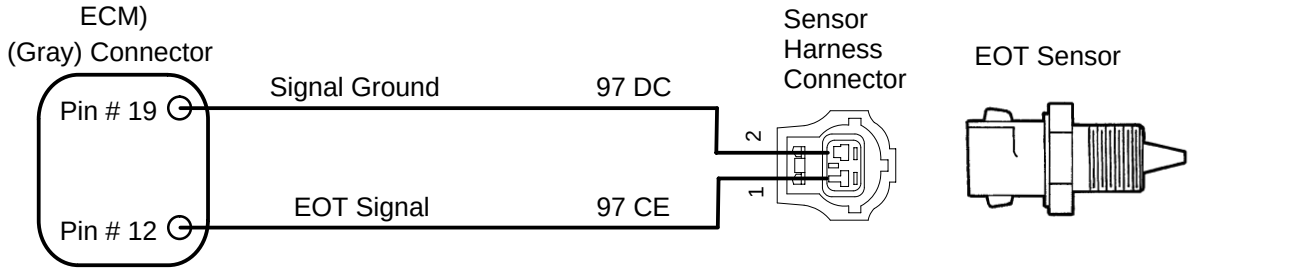
FAULT DETECTION / MANAGEMENT

An EOT signal that is detected out of range high or low by the ECM will cause the ECM to ignore the EOT signal and default to the engine coolant temperature (ECT) sensor. The Check Engine lamp will also be illuminated as long as the fault condition exists. If both the EOT and ECT sensors are not functioning, the ECM will assume a 212° F (100° C) value for engine oil temperature.

EOT - Engine Oil Temperature Sensor (Continued)

Engine Oil Temperature Sensor (EOT)

Fault Codes:
311 Out of Range Low
312 Out of Range High



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NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks
(Check with sensor connector disconnected and ignition Key in RUN position.

Test Points	Spec.	Comments
2 to Grd.	4.8 – 5.0v	Pull up voltage, if no or low voltage, circuit has open or high resistance or short to ground.
1 to Grd.	0 – .25v	If greater than 0.25 volts, signal ground wire is shorted to V Ref. or battery.

Connector Checks to Chassis Ground
(Check with sensor connector disconnected, Ignition key OFF and positive battery cable disconnected)

Test Points	Spec.	Comments
1 to Grd.	< 5 ohms	Resistance to chassis ground, check with key Off, if > than 5 ohms the harness is open.
2 to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
1 to #19	< 5 ohms	Resistance from sensor connector to 60 pin connector – Signal ground
2 to #12	< 5 ohms	Resistance from sensor connector to 60 pin connector – EOT Signal

Operational Signal Checks
(Check with breakout box installed in line with the ECM)

Test Points (+) #12 to (–) #19				
Voltage	Temp. ° F	Temp. ° C	Resistance	Comments
0.53v	248	120	1.19 K ohms	
0.96v	205	96	2 K ohms	
1.45v	176	80	3.84 K ohms	
4.36v	32	0	69.2 K ohms	
4.64v	–5	–20	131.0 K ohms	

Fault Code Descriptions

Circuit Faults:
311 = Signal was less than 0.2 volts more than 0.1 seconds.
312 = Signal voltage was greater than 4.78 volts for more than 0.1 seconds.

EOT - Engine Oil Temperature Sensor (Continued)

FUNCTION

The engine control system includes an Engine Oil Temperature (EOT) sensor. The ECM monitors engine oil temperature via the EOT sensor signal to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment. This insures that adequate power and torque are available under all operating conditions.

OPERATION

The Engine Oil Temperature Sensor is a thermistor type sensor which changes resistance when exposed to different oil temperatures.

When the temperature of the oil is decreased the resistance of the thermistor increases which causes the signal voltage to increase. As the temperature of the oil is increased, the resistance of the thermistor decreases, causing the signal voltage to decrease.

The EOT sensor is supplied a regulated 5 volt reference signal at terminal 2 from the ECM pin 12. A return circuit (ground) is supplied at terminal 1 from the ECM pin 19. As the oil temperature increases or decreases, the sensor changes resistance and provides the ECM with the oil temperature signal voltage. This signal voltage is then read by the ECM to determine the temperature of the oil.

ECM DIAGNOSTICS

With the ignition key ON, the ECM continuously monitors the EOT signal to determine if it is within expected values. If the signal voltage is above or below the expected levels, the ECM will set a fault code.

If the ECM detects a fault, it will use the value of the Engine Coolant Temperature signal, in place of the EOT signal. If the ECT sensor is not sending a correct signal, the ECM will default to -4° F (-20° C) for starting or 212° F (100° C) for engine running operation.

EOT sensor faults can be retrieved using the Electronic Service Tool or by reading the flash codes from the Check Engine lamp using the Audio Test switch to initiate an STI diagnostic test. If the ignition key is shut off, the code will become an Inactive code. EOT codes will cause the Engine Warning light to be illuminated.

FLASH CODE *311*

ATA CODE PID 175 FMI 4

Engine Oil Temperature Signal Out Of Range Low

Code 311 out of range low, will be set if the signal voltage was less than 0.2 volts for more than 0.1 seconds. If this code is set, the ECM will default to ECT temperature or a default value of -4° F (-20° C) for starting or 212° F (100° C) for engine running operation. This code will cause the ECM to illuminate the Engine Warning light.

Possible causes include:

- A short to ground in the signal circuit.
- A defective sensor.

EOT - Engine Oil Temperature Sensor (Continued)

FLASH CODE *312*

ATA CODE PID 175 FMI 3

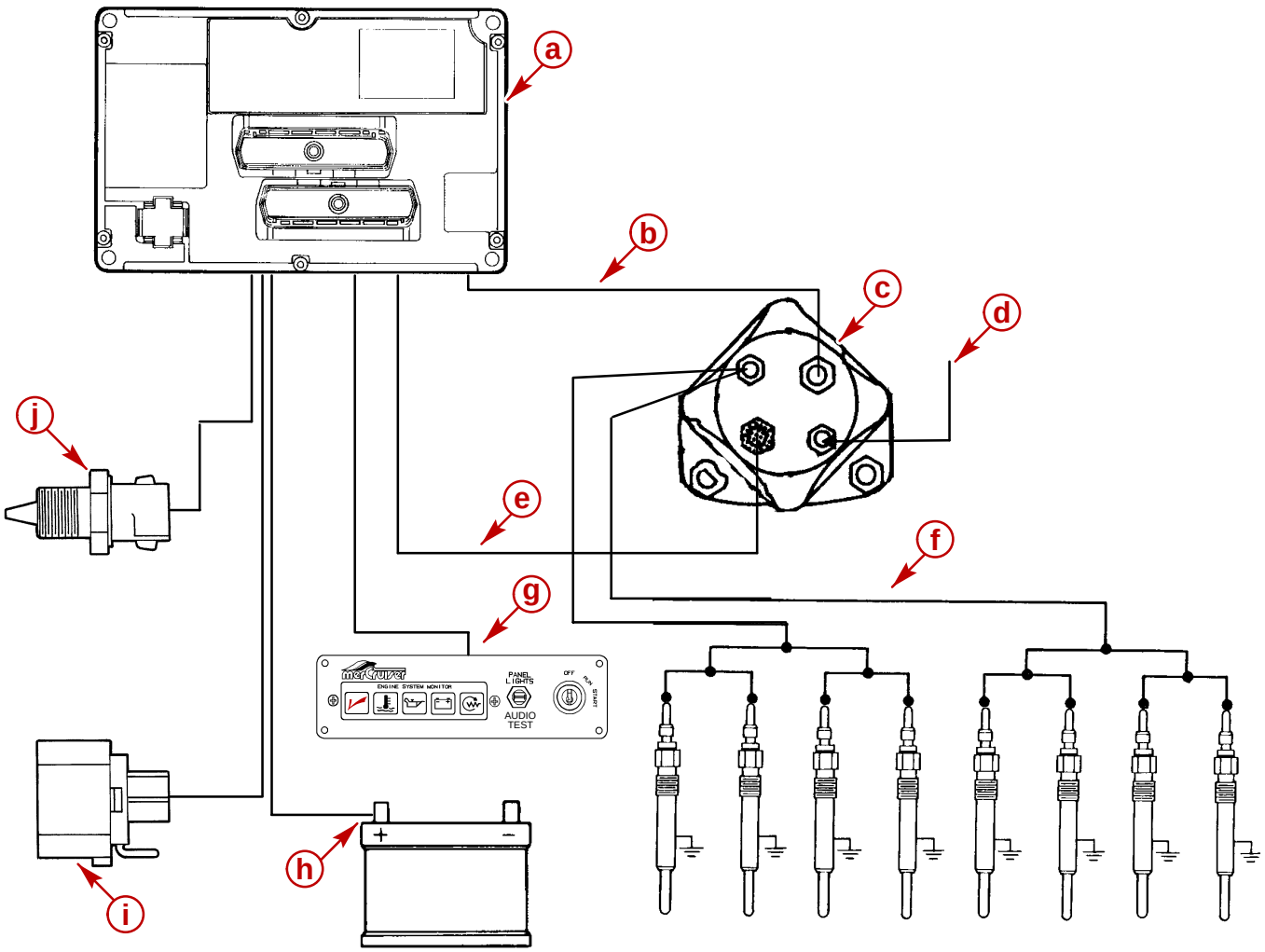
Engine Oil Temperature Signal Out Of Range High

Code 312 Out Of Range High,will be set if the signal voltage is more than 4.8 volts for more than 0.1 seconds. If this code is set, the ECM will default to ECT temperature or a default value of -4° F (-20° C) for starting or 212° F (100° C) for engine running operation. This code will cause the ECM to illuminate the Engine Check lamp.

Possible causes include:

- An open signal circuit between the ECM and the sensor.
- A short to a voltage source.
- A defective sensor.

GPC - Glow Plug Controller



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a - ECM
b - Ground (–) Signal
c - Glow Plug Relay
d - Battery Voltage From Starter Solenoid
e - Power Signal
f - Glow Plug Harness (UVC Included)
g - Preheat Indicator Lamp (Wait Lamp)
h - Battery +
i - BARO Sensor
j - ECT Sensor

GPC - Glow Plug Controller (Continued)

OUTPUT FUNCTIONS

Glow Plug Relay - Controls the current flow to the glow plugs. Glow plug relay ON time is controlled by the ECM and is a function of engine coolant temperature, barometric pressure and battery voltage. ON time normally varies between 10 to 120 seconds. The glow plugs are self limiting glow plugs and do not require to be cycled on and off. (The glow plug relay will only cycle on and off repeatedly when there is a system voltage condition greater than 13.0 volts.)

Glow Plug Wait Lamp - Lamp that indicates to the operator when the glow plugs have been on long enough to crank the engine. It is controlled by the ECM. Wait light on time is a function of engine coolant temperature, barometric pressure and battery voltage. ON time normally varies between 2 to 10 seconds.

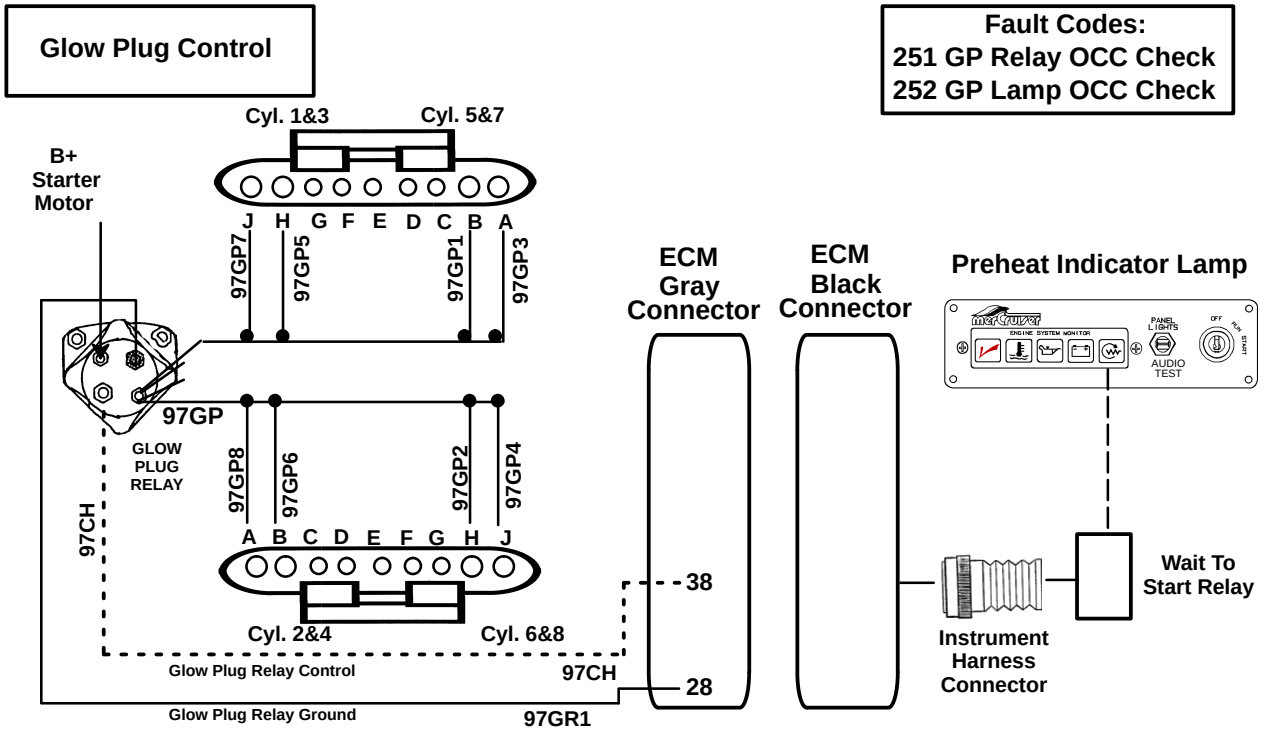
NOTE: *Wait light on time is independent from glow plug relay on time.*

FAULT DETECTION/MANAGEMENT

An open or shorted to ground glow plug relay or wait lamp circuit can be detected by an On Demand Output Circuit Check performed during the Engine Off Tests.

Glow plug and glow plug harness problems can not be detected by the ECM.

GPC - Glow Plug Controller (Continued)



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NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Glow Plug Relay Operation (Voltage Checks at Relay)		
Test Points	Spec.	Comments
B+ terminal to ground	B+	Relay switch power, B+ should be present at all times (terminal with single 6 gauge wire). Check connection at starter or fusible links if no power (voltage) present.
Glow Plug Feed to Grd.	B+	Glow plug feed voltage should be present 10 to 120 sec. after key is cycled on, dependent upon battery voltage, barometric pressure (altitude) and engine coolant temperature. (Large terminal with 5 wires.)
Cir 97CH to ground	12V, or 0V	Glow Plug Control ECM commands relay On = 12V Off = 0V
Cir 97GR1 to Ground	0V	GPC relay grounded thru ECM – If voltage present, check circuit for open.

GPC - Glow Plug Controller (Continued)

Glow Plug and Harness Operation (Measure flow plug resistance to ground with the pigtail connector installed at the valve cover connector: Then measure resistance from the glow plug feed stud to the harness connector.)			
Test Points			
Glow Plug Number	Pigtail Connector to Ground (B–)	Relay to Harness Connector	Comments
Spec.	<.1 to 6 Ohm	< 6 Ohms	**Relay to Harness Connector**
#1			**NOTE: All engine harness connectors for glow plug / injectors should be disconnected before taking measurements.**
#3			
#5			High resistance could indicate an open circuit in the engine harness between the glow plug connector and the relay.
#7			
#2			**Pigtail Connector to Ground B–**
#4			High resistance could indicate an open circuit in the UVC (under the valve cover) harness or in the glow plug.
#6			Glow plug resistance should measure 0.1 to 6 ohms dependent upon engine temperature.
#8			

Fault Code Descriptions
251 = OCC CHK performed by ECM during engine off test. Indicates high or low resistance in GP coil circuit.
252 = OCC CHK performed by ECM during engine off test. Indicates high or low resistance in GP lamp circuit.

GPC - Glow Plug Controller (Continued)

FUNCTION

The engine control system includes a Glow Plug Control System that controls the current flow to the glow plugs. Glow plug relay ON time is controlled by the ECM and is a function of Engine Coolant Temperature, Barometric Pressure, and Battery Voltage. Glow plug ON time varies between 10-120 seconds. Glow plugs are self limiting glow plugs and do not require to be cycled on and off. The glow plug relay will cycle on and off repeatedly, if battery voltage is greater than 13.0 volts.

OPERATION

Refer to circuit diagram for the following discussion.

Glow Plug System operation is dependent upon engine coolant temperature, barometric pressure and battery voltage. When the ignition switch is placed in the ON position,Terminal “B” (coil side) of the glow plug relay is supplied with battery voltage. Terminal “A” (coil side) of the relay is connected to Terminal 58 of the ECM. The ECM supplies battery ground to the glow plug relay coil via an internal driver transistor when coolant temperature, barometric pressure and battery voltage conditions require the glow plug system to warm the engine for starting.

Applying ground (B-) to terminal “A” causes the relay to switch and apply battery voltage (present at the large terminal containing a single wire leading to and connected to the B+ terminal of the starter solenoid) to the other large terminal which contains two wires. These wires now supply battery power to the glow plugs in the right and left cylinder heads.

The Preheat Indicator Lamp (Glow Plug Wait Lamp) is also turned on by the ECM when the glow plug relay and Wait to Start Relay is enabled.

NOTE: *The Preheat Indicator Lamp (Glow Plug Wait Lamp) on time is independent from glow plug relay on time.*

ECM DIAGNOSTICS

The ECM does not continuously monitor the glow plug control circuitry. An open or shorted to ground glow plug control relay on the control side (coil) circuit can be detected by an on demand output circuit check performed during the engine off test.

Fault codes can be retrieved using the electronic service tool or the Audio Test switch to initiate an STI Self Test Input diagnostic test. If the ignition key is shutoff, the code will be stored as an active code.

FLASH CODE *251*

ATA CODE SID 38 FMI 11

GPC: OCC Self Test Failed

Code 251 is set only during the Engine Off Standard Output Circuit check. This indicates that the ECM has performed an output circuit test, measured the voltage drop across the glow plug relay circuit and determined it is above or below specification. If the fault is present, the glow plug relay is not operating and the glow plugs are not enabled.

Possible causes include:

- An open feed circuit.
- An open glow plug relay coil.
- An open or shorted GPC signal circuit.

GPC - Glow Plug Controller (Continued)

FLASH CODE *252*

ATA CODE SID 36 FMI 11

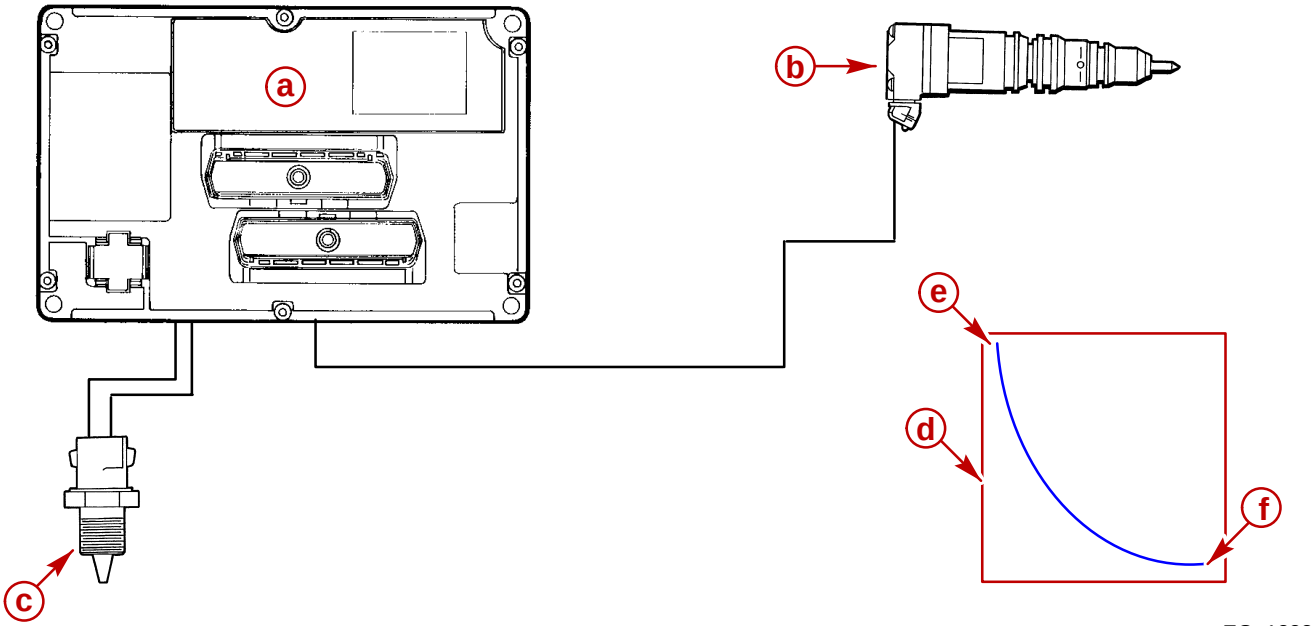
Glow Plug Lamp: OCC Self Test Failed

Code 252 is set only during the Engine Off Standard Output Circuit check. This indicates that the ECM has performed an output circuit test, measured the voltage drop across the glow plug Wait to Start Relay and Preheat Indicator Lamp circuit and determined it is above or below specification.

Possible causes include:

- Preheat Indicator Lamp burned out,
- An open or shorted glow plug Wait to Start Relay.
- An open or shorted Preheat Indicator Lamp circuit.

IAT - Intake Air Temperature Sensor



EG–1228

a - ECM
b - Fuel Quantity and Timing Control (Injectors)
c - IAT Sensor
d - IAT Signal (Analog Voltage) Graph
e - 5 Volts (Colder)
f - 0 Volts (Warmer)

SIGNAL FUNCTIONS

The Intake Air Temperature (IAT) sensor is a thermistor type sensor that has a variable resistance that changes when exposed to different temperatures. When interfaced with the ECM it produces a 0-5 volt analog signal that will deduce temperature.

The IAT sensor's primary function is to measure intake air temperature in order to control timing and fuel rate while starting the engine in cold weather to limit smoke emissions.

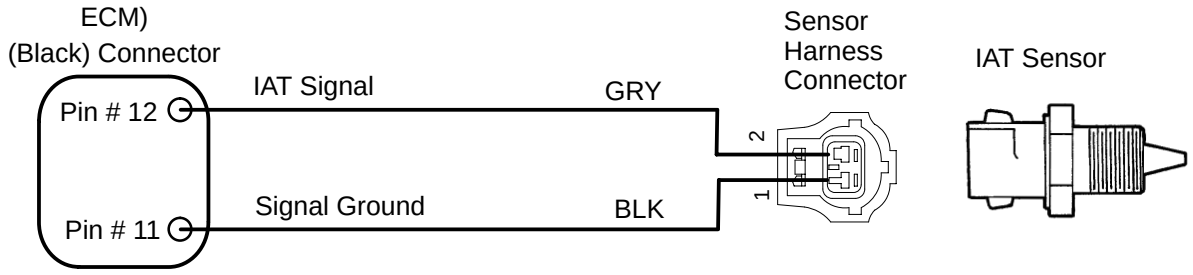
FAULT DETECTION/MANAGEMENT

An IAT signal that is detected out of range high or low by the ECM will cause the engine to ignore the IAT signal and to default to an ambient temperature of 77° F (25° C).

IAT - Intake Air Temperature Sensor (Continued)

Intake Air Temperature Sensor (IAT)

Fault Codes:
154 Out of Range Low
155 Out of Range High



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks
(Check with sensor connector disconnected and Ignition Key ON)

Test Points	Spec.	Comments
1 to Grd.	0 – .25 v	If greater than 0.25 volts, signal wire is shorted to V Ref or battery.
2 to Grd.	4.6 – 5.0v	Pull up voltage, if no voltage, circuit has open or high resistance or short to grd.

Connector Checks to Chassis Ground
(Check with sensor connector disconnected, positive battery cable disconnected & Ignition key OFF)

Test Points	Spec.	Comments
1 to Grd.	< 5 ohms	Resistance to chassis ground, check with key OFF, if greater than 5 ohms the harness is open.
2 to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks
(Check with breakout box installed on chassis harness only)

Test Points	Spec.	Comments
#11 to 1	< 5 ohms	Resistance from sensor connector to 60 pin connector – Signal ground
#12 to 2	< 5 ohms	Resistance from sensor connector to 60 pin connector – IAT Signal

Test Points (+) #12 to (–) #11		**Operational Signal Checks (Check with breakout box installed in line with the ECM)**		
Voltage	Temp. ° F	Temp. ° C	Resistance	Comments
1.72v	122	50	10.9 K ohms	Resistance checks must be taken across sensor only with battery disconnected.
3.09v	68	20	37.34 K ohms	
3.897v	32	0	68.75 K ohms	
4.33v	0	–18	120.9 K ohms	
4.537v	–40	–40	194.3 K ohms	

Fault Code Descriptions

Circuit Faults:
154 = Signal voltage was less than .127 volts more than 0.2 seconds.
155 = Signal voltage was greater than 4.6 volts for more than 0.2 seconds.

IAT - Intake Air Temperature Sensor (Continued)

FUNCTION

The engine control system includes an Intake Air Temperature Sensor (IAT). The ECM measures the signal from the IAT sensor to determine the temperature of the air entering the engine. The ECM uses this data to adjust timing and fuel rate for starting in cold weather to limit smoke emissions.

OPERATION

The Intake Air Temperature Sensor is a thermistor type sensor which changes resistance when exposed to different air temperatures.

When the temperature of the intake air decreases, the resistance of thermistor increases which causes the signal voltage to increase. When the air temperature increases, the resistance of the thermistor decreases causing the signal voltage to decrease.

The IAT sensor is supplied a regulated 5 volt reference signal, at terminal 2 of the sensor connector, from the ECM. A return circuit (ground) is supplied at terminal 1 from the ECM. As the air temperature increases or decreases, the sensor changes resistance and provides the ECM with the air temperature signal voltage reading.

ECM DIAGNOSTICS

With the ignition key ON, the ECM continuously monitors the IAT signal to determine if it is within expected values. If the signal voltage is above or below the expected levels, the ECM will set a fault code.

If the IAT sensor is not sending a correct signal, the ECM will default to 77° F (25° C).

IAT faults can be retrieved using the Electronic Service Tool or by reading the flash codes from the Check Engine lamp using the Audio Test switch to initiate an STI diagnostic test. If the ignition key is OFF, the code will become an Inactive code. IAT codes will cause the Engine Warning light to be illuminated.

FLASH CODE *154*

ATA CODE PID 171 FMI 4

Ambient Air Temp Signal Out Of Range Low

An out of range low code will be set if the ECM detects the signal voltage to be less than .127 volts for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77° F (25° C) for starting.

Possible causes include:

- A short to ground in the signal circuit.
- A defective sensor.

IAT - Intake Air Temperature Sensor (Continued)

FLASH CODE *155*

ATA CODE PID 171 FMI 3

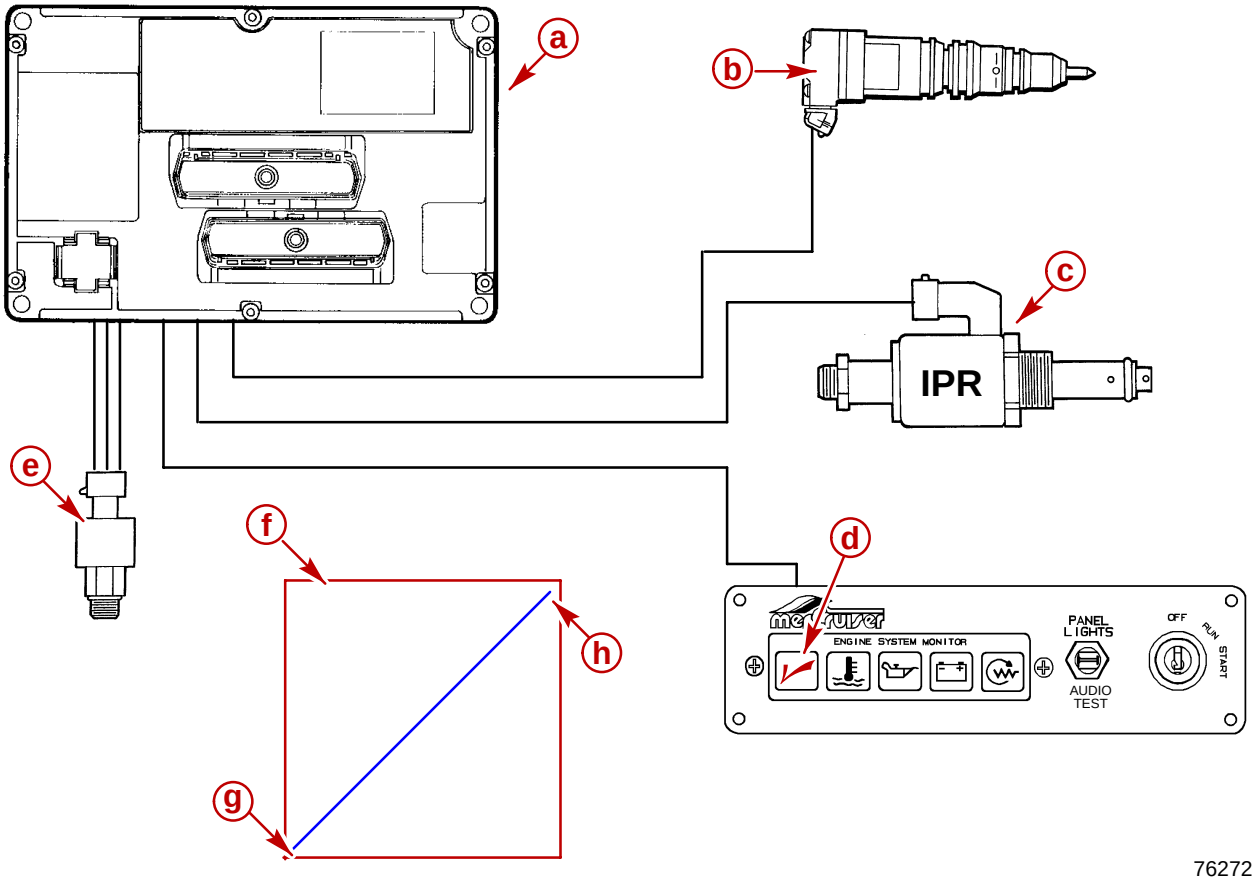
Ambient Air Temp Signal Out Of Range High

An out of range high code will be set if the ECM detects the signal voltage to be more than 4.6 volts for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77° F (25° C) for starting.

Possible causes include:

- An open signal circuit between the ECM and the sensor.
- A short to a voltage source in signal circuit between the ECM and the sensor.
- A defective sensor.

ICP - Injection Control Pressure Sensor



a - ECM
b - Fuel Quantity and Timing Control (Injectors)
c - IPR Valve
d - Check Engine Lamp
e - ICP Sensor
f - ICP (Analog Voltage) Signal Chart
g - 0 Volts (Less Pressure)
h - 5 Volts (More Pressure)

SIGNAL FUNCTIONS

The Injection Control Pressure (ICP) sensor is a variable capacitance sensor that when supplied with a 5 volt reference signal from the ECM produces a linear analog voltage signal that indicates pressure.

The ICP sensor's primary function is to provide a feedback signal to indicate injection control pressure to enable the ECM to command the correct injector timing and pulse width and the correct injection control pressure for proper fuel delivery at all speed and load conditions.

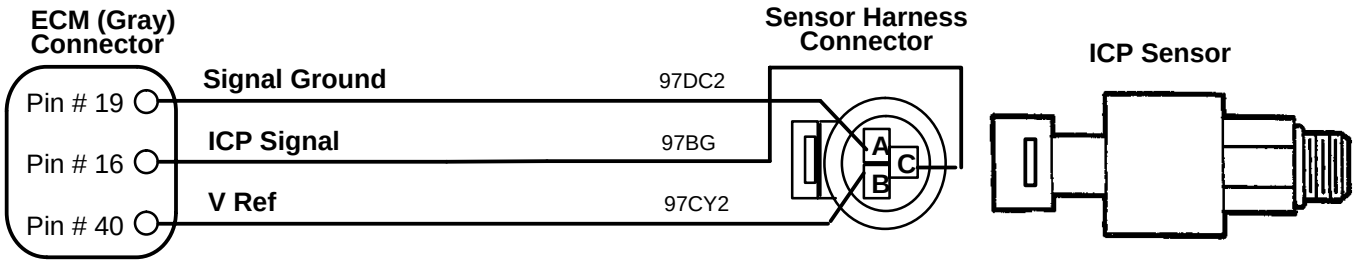
FAULT DETECTION/MANAGEMENT

If the ECM detects a malfunctioning ICP sensor, the WARN lamp will illuminate. The ECM will go to open loop control of injection control pressure. (Operate from an estimated ICP pressure.)

ICP - Injection Control Pressure Sensor (Continued)

Injection Control Pressure Sensor (ICP)

Fault Codes:
124 Out of Range Low
125 Out of Range High
332 Signal Above Spec. w/Eng. Off



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks
(Check with sensor Connector Disconnected and Ignition Key in RUN)

Test Points	Spec.	Comments
A to Grd.	0 volts	Signal ground, no voltage signal expected
B to Grd.	5 volts ± .5	V Ref check with key in RUN, if voltage not in spec., see V Ref circuit
C to Grd.	< .25 volts	If greater than 0.25 volts, signal ground wire is shorted to V Ref. or battery.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected, Positive Battery Cable Disconnected and Ignition key OFF)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground, check with key off, if greater than 5 ohms the harness is open.
B to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#19 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector – Signal ground
#40 to B	< 5 ohms	Resistance from sensor connector to 60 pin connector – V Ref
#16 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector – ICP signal

Test Points (+) #16 to (–) #19		**Operational Voltage Checks (Check with breakout box installed on ECM and Engine (Gray) harness)**	
Voltage	PSI	MPA	Comments
.15 – .30v	0	0	Atmospheric pressure with Key in RUN and Engine OFF. (Altitude dependent)
1.0v	580	4	Minimum required at engine cranking speed 150 RPM
.74 – .81v	425 – 475	2.9 – 3.2	Normal warm idle voltage signal (See Performance Specs.)
1.34 – 1.68v	865 – 1157	6.0 – 8.0	Normal high idle voltage signal (See Performance Specs.)
2.8 – 3.2v	2175 – 2405	15 – 17	Snap accel or full load pressure signal (See Performance Specs)

Fault Code Descriptions

Circuit Faults:
124 = Signal voltage was less than .039 volts for more than 1.0 seconds
125 = Signal voltage was greater than 4.90 volts for more than 1.0 seconds.
332 = Signal above 1.625 volts with engine off. (1160 psi, 8 MPa)

ICP - Injection Control Pressure Sensor (Continued)

FUNCTION

The engine control system includes an Injection Control Pressure Sensor. The ECM measures the signal from the ICP sensor to determine the Injection Control Pressure as the engine is running to modulate the Injection Control Pressure Regulator. This is a closed loop function which means the ECM continuously monitors and adjusts for ideal Injection Control Pressure determined by operating conditions such as load, speed, and temperature.

The ECM monitors the ICP signal to determine if the performance of the hydraulic system is satisfactory. During engine operation, if the ECM recognizes that the pressure reading is lower or higher than the value that was commanded, the ECM will set a fault code. This strategy is also used during the On Demand tests, commanded by the Electronic Service Tool and referred to as the Engine Running tests.

OPERATION

The ICP signal voltage increases or decreases equally in proportion to an increase or decrease in injection control pressure.

The Injection Control Pressure Sensor is a variable capacitance sensor that is supplied with a 5 volt reference voltage at terminal B of the ICP Sensor from the ECM terminal 40. The ICP sensor is also supplied with a return circuit (ground) at terminal A of the ICP Sensor from the ECM terminal 19. The ICP sensor sends a signal from terminal C of the sensor to ECM terminal 16.

ECM DIAGNOSTICS

The ECM continuously monitors the signal of the ICP sensor to determine if the signal is within an expected range. If the signal voltage is higher or lower than expected, the ECM will set a fault code. The ECM will then ignore the ICP sensor signal and will use a preset value determined by engine operating conditions. If the ignition key is shut off, the code will become an Inactive code.

ICP faults can be retrieved using the Electronic Service Tool or by reading the flash codes from the warning light using the STI diagnostic switch.

If the ignition key is shut off, the code will become an Inactive code. ICP codes will cause the Engine Warning light to be illuminated.

ICP - Injection Control Pressure Sensor (Continued)

FLASH CODE *124*

ATA CODE PID 164 FMI 4

ICP Signal Out Of Range Low

An out of range low code 124 will be set by the ECM if the signal voltage is less than .039 volts for more than 1.0 seconds.

Possible causes include:

- An open or short to ground on the signal circuit.
- An open V Ref circuit.
- A defective sensor.

FLASH CODE *125*

ATA CODE PID 164 FMI 3

ICP Signal Out Of Range High

An out of range high code 125 will be set by the ECM if the signal voltage is greater than 4.9 volts for more than 1.0 seconds.

Possible causes include:

- An open return circuit.
- A defective sensor.

FLASH CODE *332*

ATA CODE PID 164 FMI 13

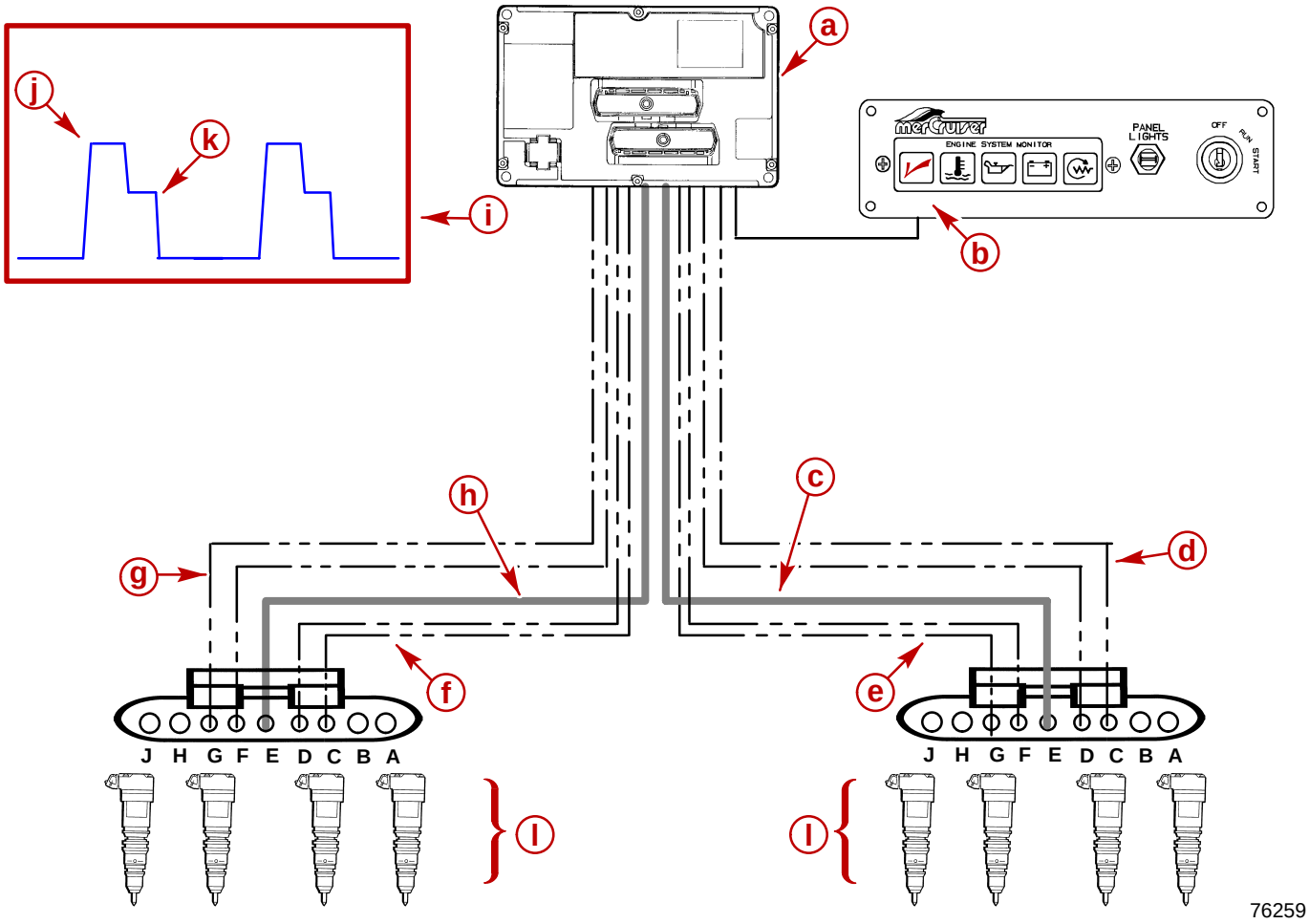
Injection Control Pressure Above Specification With Engine OFF

Code 332 will be set by the ECM, if the signal from the ICP sensor is higher than expected with the engine not running. If the ECM detects this fault, the ECM will ignore the ICP signal and will operate the IPR with fixed values determined from engine operating conditions.

Possible causes include:

- A defective sensor.
- A biased circuit.

Injector Drive Circuit Operation



a - ECM
b - Engine Check Lamp
c - Right High Side Driver (115 Volt DC)
d - Low Side Drive Signals
e - Low Side Drive Signals
f - Low Side Drive Signals
g - Low Side Drive Signals
h - Left High Side Driver (115 Volt DC)
i - Injector Drive Signal Chart
j - 7 Amps
k - 3.5 Amps
l - Fuel Quantity and Timing Control

Injector Drive Circuit Operation (Continued)

CIRCUIT FUNCTIONS

High Side Drive Outputs – The high side drive outputs control the injector “On Time” (fuel quantity), injection timing (in relation to TDC) and sequencing (firing order). The ECM controls each individual injector by supplying current to each injector solenoid.

Low Side Drive Returns – The injector solenoids are grounded through the low side return circuits. The ECM monitors the low side return signal for diagnostic purposes and utilizes the fly-back current from the injector solenoids to help charge the drive capacitors internal to the ECM.

FAULT DETECTION MANAGEMENT

The ECM is capable of detecting, while the engine is running, individual injector open or short circuits either to ground or battery voltage. It is also capable of detecting right or left bank low side open or shorts to ground. A fault code will be set and the CHECK ENGINE lamp will be illuminated when these conditions occur.

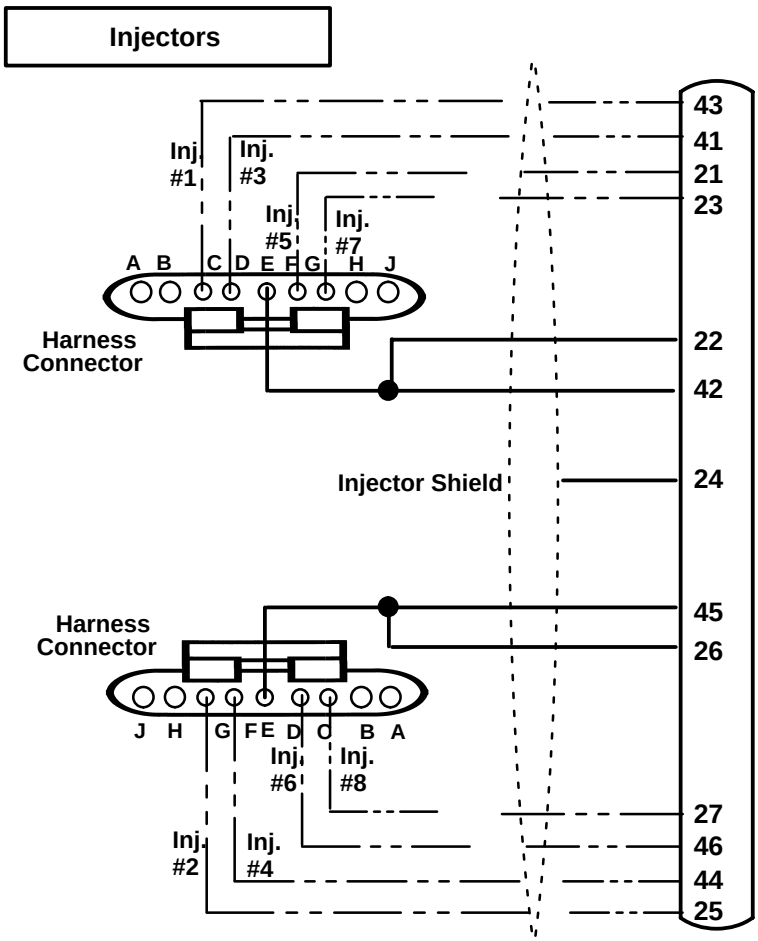
A special On-Demand Buzz test is also available to the technician to enable (“Buzz”) the injectors while being serviced, to verify circuit operation.

If a short to ground condition is detected on a high or low side circuit, the ECM will discontinue operation of the affected bank of injectors, turn on the Check Engine lamp and continue to operate on four cylinder operation.

⚠ CAUTION

Avoid serious injury or equipment damage. Injector circuits and injector solenoids operate on 115 Volts Direct Current at 10 amperes. DO NOT perform voltage checks with the engine running.

Injector Drive Circuit Operation (Continued)



Fault Codes:

NOTE: (Last code digit refers to INJ or Bank #)

421-428 High to low side open inj. #1-#8
431-438 High to low side short inj. #1-#8
441-448 Low side short to B+ inj. #1-#8
451-458 Low side short to grd. inj. #1-#8
513 Low side to Bank 1 Open (Right Bank)
514 Low side to Bank 2 Open (Left Bank)
515 Bank 1 Low Side Short to Ground or B+ (Right Bank)
521 Bank 2 Low Side Short to Ground or B+ (Left Bank)
524 Both High side switches shorted together
525 Injector driver circuit fault

76260

NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Individual circuit test information not available at time of printing.

Injector Drive Circuit Operation (Continued)

⚠ CAUTION

Avoid serious injury or equipment damage. Injector solenoids operate on voltages of 115 Volts Direct Current at 10 amperes is present on injector circuits. DO NOT perform voltage checks with the engine running.

FUNCTION SYSTEM DESCRIPTION

NOTE: *The ECM uses the fuel quantity control strategy and input from the engine sensors to determine how long each fuel injector is actuated in order to provide the proper fuel quantity at any given engine operating condition.*

INJECTOR DIAGNOSTICS

The ECM monitors the voltage on the driver circuits and is capable of detecting an open or shorted circuit. If the ECM detects a short to ground or a multiple fault in a driver, the ECM will discontinue operation of that driver which would cause the engine to operate on the remaining bank of 4 cylinders. The ECM will set a fault code, illuminate the Check Engine lamp and compensate for inoperative cylinders to keep the engine running if mechanically possible.

Faults can be retrieved using the Electronic Service Tool or the Audio Test switch to initiate a STI Self Test Input Diagnostic test.

NOTE: *The last digit of the flash code indicates the affected cylinder number. For example, code 421 indicates cylinder no. 1 has an open circuit between the ECM high side driver and the low side (signal return) to the ECM. The SID no.s 1-8, indicate cylinder no.s in a similar manner.*

FLASH CODE *421 Through 428*

ATA CODE SID 1 THROUGH 8 FMI 5

High Side To Low Side Open

Flash Codes for High Side to Low Side Open indicate an open circuit between the ECM high side driver and the low side (Signal return) to the ECM.

The ECM will compensate for engine misfire to keep the engine operating. The ECM will not illuminate the Check Engine lamp when this situation occurs.

Possible causes include:

- Open wire in injector harness.
- Open injector return circuit
- Open injector solenoid.

Injector Drive Circuit Operation (Continued)

FLASH CODE *431 Through 438*

ATA CODE SID 1 THROUGH 8 FMI 4

High Side Shorted To Low Side

Flash codes for High Side Shorted to Low Side indicate the return voltage is too high due to a short circuit between the high side driver and return circuit.

The ECM will compensate for engine misfire to keep the engine operating. The ECM will not illuminate the Check Engine lamp when this situation occurs.

Possible causes include:

- Shorted injector solenoid.
- Shorted wiring harness.

FLASH CODE *451 THROUGH 458*

ATA CODE SID 1 THROUGH 8 FMI 6

Low Side Shorted To Ground

Flash codes for Low Side Shorted to Ground indicate the return circuit shorted to ground.

If the ECM detects this fault, it will disable the entire bank of cylinders associated with the cylinder indicated.

Possible causes include:

- Shorted injector solenoid.
- Wiring harness shorted to ground.

FLASH CODE *513*

ATA CODE SID 151 FMI 5

High Side Open, Right Group

With High Side Open Right Group (Bank 1), the ECM has detected an open circuit to the injectors on cylinders 1, 3, 5, or 7.

With flash code 513 active, the drivers for cylinders 1, 3, 5, and 7 are inoperative. The ECM will compensate for misfire to keep the engine operating and will illuminate the Check Engine lamp.

FLASH CODE *514*

ATA CODE SID 152 FMI 5

High Side Open Left Group

With the High Side Open Left Group (Bank 2), the ECM has detected an open circuit to the injectors on cylinders 2, 4, 6 and 8.

With flash code 513 active, the drivers for cylinders 2, 4, 6 and 8 are inoperative. The ECM will compensate for misfire to keep the engine operating and will illuminate the Engine Warning light.

Injector Drive Circuit Operation (Continued)

FLASH CODE *515*

ATA CODE SID 151 FMI 6

High Side Bank 1 Short To Ground Or B+

Flash code 515 indicates the ECM has detected the high side driver for cylinders 1, 3, 5 and 7 has excessive current draw.

With flash code 515 active, the driver for cylinders 1, 3, 5 and 7 will be disabled. The ECM will compensate for engine misfire to keep the engine running. This code will cause the Check Engine lamp to be illuminated.

FLASH CODE *521*

ATA CODE SID 152 FMI 6

High Side Bank 2 Short To Ground Or B+

Flash code 521 indicates the ECM has detected excessive current draw on high side driver for cylinders 2, 4, 6 and 8.

With flash code 521 active, the driver for cylinders 2, 4, 6 and 8 will be disabled. The ECM will compensate for engine misfire to keep the engine operating and will illuminate the Check Engine lamp.

FLASH CODE *524*

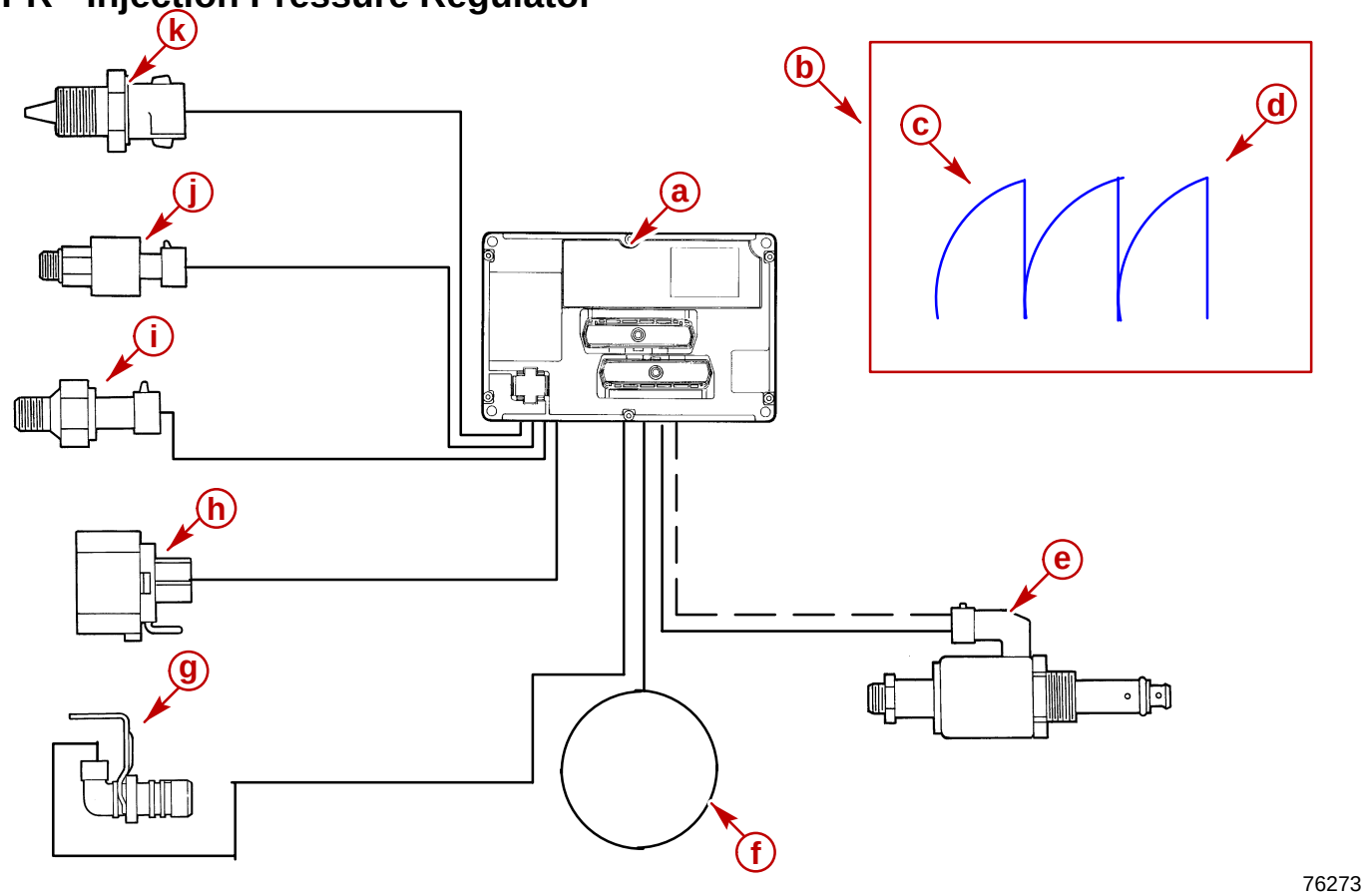
ATA CODE SID 151 FMI 3

BOTH HIGH SIDE SWITCHES SHORTED TOGETHER

Flash code 524 indicates a short circuit between the two high side drivers.

With this code active, the Check Engine Lamp will be illuminated.

IPR - Injection Pressure Regulator



76273

Injection Pressure Regulator Function Diagram

- **a** - ECM
- **b** - IPR Output Signal Chart - Duty Cycle Controlled
- **c** - !2 Volts
- **d** - 400 Hz
- **e** - IPR Valve
- **f** - APS/IVS Sensor
- **g** - CMP Sensor
- **h** - BARO Sensor
- **i** - MAP Sensor
- **j** - ICP Sensor
- **k** - EOT Sensor

IPR - Injection Pressure Regulator (Continued)

OUTPUT FUNCTIONS

Injection Pressure Regulator - Is a variable position valve that controls injection control pressure. The ECM uses many input variables to determine the desired injection control pressure.

Battery voltage is supplied to the IPR when the ignition key is in the on position. Valve position is controlled by switching the output signal circuit to ground inside the Electronic Control Module (ECM). On off time is modulated from 0-60% dependent upon the desired injection control pressure.

FAULT DETECTION/MANAGEMENT

An open or a short to ground control circuit can be detected by an on demand output circuit check performed during the engine off test.

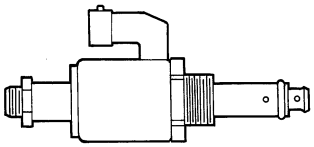
The ECM is capable of detecting, while the engine is running, if desired injection control pressure is equal to measured injection control pressure. If the measured injection control pressure does not reasonably compare to the desired injection control pressure, the ECM ignores the measured ICP signal and attempts to control the engine with the desired value. (If the problem was in the sensor circuit, this strategy causes little performance deterioration, if the problem is in the control circuit, engine performance will probably still be unsatisfactory).

A faulty IPR or problem with the high pressure oil system can be detected by the engine running test during the injection control pressure step test. During this test, the ECM commands and measures two specific pre programmed pressures. A fault code is set, if the pressures can not be maintained.

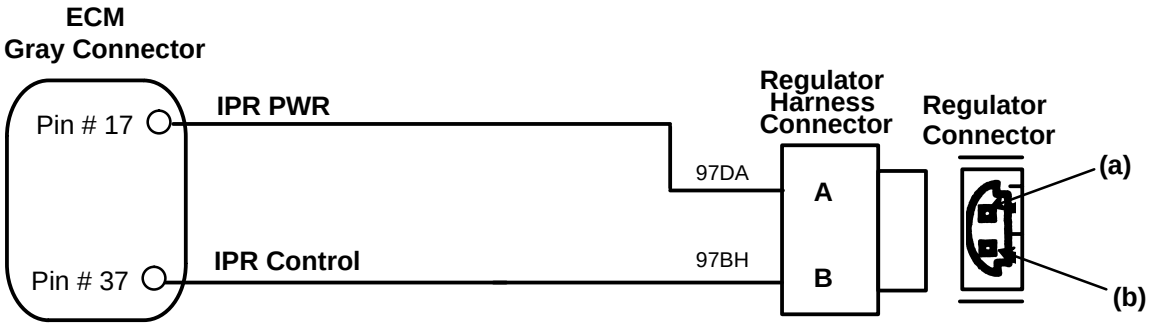
IMPORTANT: <u>The engine will not operate with an IPR circuit that is not functioning.</u>

IPR - Injection Pressure Regulator (Continued)

Injection Pressure Regulator (IPR)



Fault Codes:
241 Output Circuit Check
331 Excessive ICP Pressure



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

IPR Voltage Check
(Check with regulator connector disconnected and ignition key in RUN position.)

Test Points	Spec.	Comments
A to Grd.	B+	IPR power voltage from ECM
B to Grd;	0 – .25v	If greater than .25 volts, signal wire is shorted to V Ref. or battery.

Connector Checks to Ground (B–)
(Check with IPR Connector Disconnected and Ignition key off, Positive Battery Cable disconnected)

Test Points	Spec.	Comments
A to Grd.	> 1000 ohms	Resistance to chassis ground. If less than 1000 ohms, check for short to ground in circuit. Remove fuse F5 in fuse box prior to measuring resistance.
B to Grd;	> 1000 ohms	

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#17 to #37	5 to 20 ohms	Resistance through entire IPR circuit including regulator, check with regulator connector connected to IPR.
#17 to A	< 5 ohms	
37 to B	< 5 ohms	Resistance from 60 pin connector to regulator connector.

Fault Code Descriptions

241 = Output circuit check detected during Standard Test, indicates high or low resistance in circuit.
331 = ICP pressure was greater than 3675 PSI (25 MPA) for 1.5 seconds. (Possible grounded IPR control circuit.) Refer to injection control pressure diagnostics if not an electronic fault.

IPR - Injection Pressure Regulator (Continued)

FUNCTION

The engine control system includes a Injection Pressure Regulator (IPR) valve that controls oil pressure in the high pressure injection control system which is used to actuate the injectors. The IPR valve consists of a solenoid, poppet and spool valve assembly and is mounted in the high pressure oil pump. The ECM regulates injection control pressure by controlling the duty cycle (or ON / OFF time) of the injection control pressure solenoid. This increase or decrease of ON / OFF time positions a poppet valve and spool valve internal to the IPR, which in turn either maintains pressure in the injection control pressure system or vents pressure to the oil sump via the front cover.

OPERATION

The IPR valve is supplied with voltage at terminal “A” of the IPR connector when the ignition key is turned on. Control of the injection control system is accomplished by the ECM grounding the IPR circuit from terminal “B” of the IPR valve thru pin #37 of the ECM. Precise control is accomplished by varying the pulse width or percentage of “ON / OFF” time of the IPR solenoid. The frequency of the pulse width to the IPR is 400 Hz, normal “ON / OFF” times varies from 8% to 50%. A high duty cycle indicates a high amount of injection control pressure being commanded, a low duty cycle is an indication of less pressure being commanded.

ECM DIAGNOSTICS

The ECM monitors the Injection Control Pressure while the engine is in operation. If the actual pressure is greater or less than the desired pressure, the ECM will set a fault code. When this occurs, the ECM will ignore the ICP sensor and control the engine using pre-programmed values for the IPR.

The Electronic Service Tool is used to Perform the Engine Running Standard Test which enables the ECM to vary the command signal to the IPR and monitor the performance of the Injection Control Pressure system. If the system does not respond within the specified parameters, the ECM will set a fault code.

Fault codes can be retrieved using the Electronic Service Tool or the Audio Test switch (Self Test Input diagnostic switch) located on the vessel dash. If the ignition key is turned OFF, the code will be stored as an Inactive code.

IPR - Injection Pressure Regulator (Continued)

FLASH CODE *241*

ATA CODE SID 42 FMI 11

Injection Control Pressure Regulator OCC Self Test Failed

Code 241 is set only during the Engine Off Standard Output Circuit Check. This test indicates the ECM has performed an output circuit test, measured voltage drop across the IPR circuit and determined it is below or above specification.

If this fault is present, the engine will not run. The ECM will not illuminate the Check Engine lamp if this code is active. However, this code will be transmitted at the completion of the Output Circuit Check, using the Audio Test switch to initiate an STI Test or using the Electronic Service Tool.

Possible causes include:

- Open feed circuit or fuse to the IPR.
- Open IPR solenoid
- Open or shorted IPR signal circuit.

FLASH CODE *331*

ATA CODE PID 164 FMI 0

Injection Control Pressure Above System Working Range

Code 331 indicates the ECM has detected injection control pressure greater than 3675 PSI (25 MPA) which is greater than the maximum allowable working pressure.

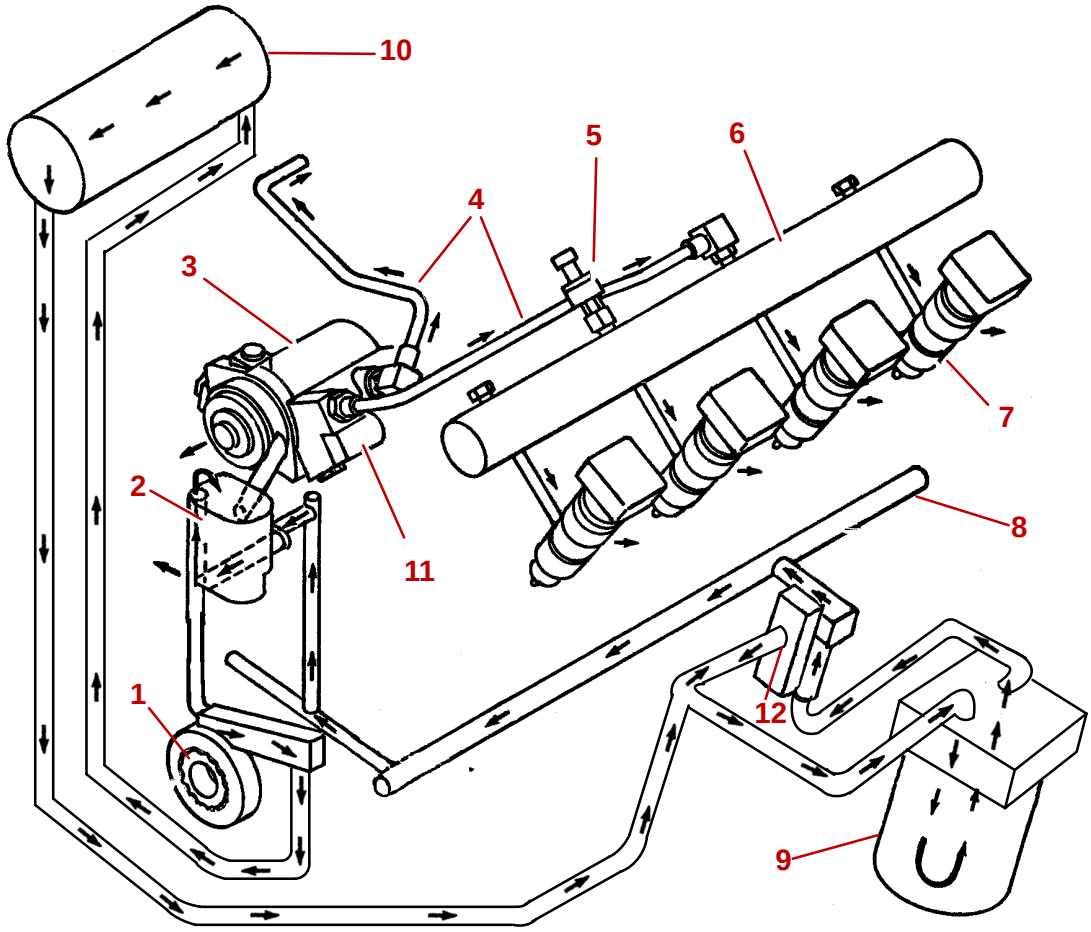
When this code is active, the ECM will illuminate the Engine Warning light.

Possible causes include:

- Incorrect ICP signal due to faulty circuits or sensor.
- Grounded IPR signal circuit.
- A malfunction in the injection control pressure system.
- A sticking or blocked IPR valve.

Refer to Injection Control Pressure system diagnostics.

IPR_SYS - Injection Pressure Regulation System



76258

Injection Pressure Regulation System

1 - Oil Pump
2 - Reservoir (Located On Top of Front Cover)
3 - High Pressure Pump
4 - High Pressure Hoses
5 - ICP Sensor
6 - Cylinder Head High Pressure Rail
7 - Injector (8)
8 - Gallery (Crankcase)
9 - Oil Filter
10 - Oil Cooler
11 - ICP Regulator (IPR) Valve
12 - Oil Filter By-Pass Valve/Oil Pressure Regulator

IPR_SYS - Injection Pressure Regulation System (Continued)

SYSTEM FUNCTIONS

The Injection Control Pressure System consists of the low pressure oil lubrication system, passages in the front cover and reservoir, high pressure oil pump, high pressure oil line as well as the high pressure oil rails machined in the cylinder heads. The injection control pressure system also includes the injectors (and their sealing O-rings), the IPR valve and the ICP sensor and associated wiring.

The function of this system is to develop, maintain and control the high pressure injection control pressure to provide the force to actuate the injectors and provide fuel to the engine.

FAULT DETECTION / MANAGEMENT

The fault codes associated with this system may indicate an electrical or electronic control system failure, but ***most likely will indicate a mechanical or hydraulic problem with the injection control pressure system.***

The ECM constantly monitors the injection control pressure in the system to assure the control system is providing the proper control pressure at all times. If the oil pressure feedback provided by the ICP sensor does not meet the ECM's programmed desired values, the ECM will set a fault code, illuminate the Check Engine lamp and control the operation of the injection control system by calculating the correct oil pressure for all engine operating conditions until the system is diagnosed and repaired.

The ECM also monitors the injection control pressure developed while cranking the engine. If pressure does not develop within the ECM's expected time limit, it will set an appropriate fault code which will aid the technician in diagnosing the no start or hard start condition.

The Electronic Service Tool (EST) may be used by the technician to command the ECM to perform an engine running test on the Injection Control Pressure system. The ECM controls the pressure regulator in a programmed sequence to evaluate system performance. At the end of the test, the ECM will transmit any fault codes if system performance is unsatisfactory.

INJECTION CONTROL PRESSURE REGULATOR TESTING

FLASH CODE *331*

ATA CODE PID 164 FMI 0

ICP (Injection Control Pressure) Above Working System Range

The purpose of flash code 331 is to detect when the injection control pressure is above it's normal working range. (3675 psi or 25mPA) This code may indicate a mechanical injection control pressure system problem, a wiring or ICP sensor problem. When this code is set the Check Engine lamp is illuminated and the ECM ignores the ICP sensor signal and uses estimated ICP values to operate the engine.

NOTE: *If the engine still performs well when this code is set, the problem is more likely in the ICP Sensor circuit.*

Possible causes include:

- Contaminated or improper grade of engine oil
- Defective or stuck injection pressure regulator (IPR) valve
- Improperly matched parts (IPR valve, high pressure pump, front cover)
- Grounded IPR control wire
- Problems with ICP sensor or circuit causing signal to be biased high

IPR_SYS - Injection Pressure Regulation System (Continued)

FLASH CODE *333*

ATA CODE PID 164 FMI 10

Injection Control Pressure Above/Below Desired Level

Code 333 may be set during normal engine operation through the continuous monitor function or during the Engine Running Standard Test. It indicates that the measured pressure does not match the pressure value which the ECM expects. Code 333 will be set if the measured value is greater or less than 362 psi (2.5 MPA) of desired injection control pressure for a period greater than 7 seconds.

When this code is active, the ECM will ignore feedback from the ICP sensor and control the IPR valve to control the pressure in the system from pre-programmed default values. When this occurs it will illuminate the Check Engine lamp to notify the operator.

Possible causes include:

- Low oil level, contaminated or aerated engine oil.
- Trapped air in the ICP system (particularly after an injector or high pressure pump replacement).
- Defective or stuck injection pressure regulator.
- Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve, poorly crimped terminals or pulled back pins.
- Leaking injector O-rings.
- Problem with ICP sensor and sensor circuit, system biased high or low.

Refer to the following table for the recommended actions for a flash code 333.

☞ **Recommended Actions:**	
Test	**Comments**
Check repair history – (Determine if air entrapment could be caused by ICP system disassembly)	If system was disassembled assure vehicle is operated 15 to 20 miles after injection control system has been serviced.
Check oil level and quality	Check for level and contamination and correct API classification.
Check active and inactive faults	Repair any ICP sensor codes first.
Perform a Key ON Engine OFF Standard Test	Test will verify IPR valve circuit continuity.
Perform a Key ON Engine Running test	ICP step test will verify a gross ICP system failure.
Perform Engine Running wiggle test *Intermittent fault detection test*	When engine is running enable test, pull/ wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If fault is set or engine dies, inspect wires at point of connection, check codes.
Perform ICP Pressure test – Performance Diagnostic form (Oil aeration)	Will verify if oil is aerated at high idle.
Test high pressure (injection control pressure system) for leaks.	Refer to ICP Leakage Tests.

IPR_SYS - Injection Pressure Regulation System (Continued)

FLASH CODE *334*

ATA CODE PID 164 FMI 7

Injection Control Pressure Unable To Reach Setpoint-poor Performance

Flash code 334 will be set if a rapid increase in injection control pressure is not developed when commanded by the operator while the engine is running. Code 334 is a ICP system response time fault that compares measured injection control pressure to desired injection control pressure and looks for a large pressure difference 1300 psi (9 MPA) for a short period of time (3 seconds). The primary function is to detect injection control pressure system faults. When this code is active, the engine warning lamp will be illuminated and the ECM will ignore the ICP sensor and control IPR valve operation from pre–programmed default values.

An active code 334 is usually associated with poor engine performance conditions including slow time to acceleration and lower power concerns.

Possible causes include:

- Low oil level, contaminated or aerated engine oil.
- Trapped air in the ICP system (particularly after an injector or high pressure pump replacement.
- Defective or stuck injection pressure regulator.
- Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve, poorly crimped terminals or pulled back pins.
- Leaking injector O-rings.
- Problem with ICP sensor and sensor circuit, system biased high or low.

Refer to the following table for the recommended actions for a flash code 334.

☞ **Recommended Actions:**

Test	Comments
Check repair history – (Determine if air entrapment could be caused by ICP system disassembly)	If system was disassembled assure vehicle is operated 15 to 20 miles after injection control system has been serviced.
Check oil level and quality	Check for level and contamination and correct API classification.
Check active and inactive faults	Repair any ICP sensor codes first.
Perform a Key ON Engine OFF Standard Test	Test will verify IPR valve circuit continuity.
Perform a Key ON Engine Running test	ICP step test will verify a gross ICP system failure.
Perform Engine Running wiggle test – *Intermittent fault detection test*	When engine is running enable test, pull/ wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If fault is set or engine dies, inspect wires at point of connection, check codes.
Perform ICP Pressure test – (Oil aeration)	Will verify if oil is aerated at high idle.
Test high pressure (injection control pressure system) for leaks.	Refer to ICP Leakage Tests.

IPR_SYS - Injection Pressure Regulation System (Continued)

FLASH CODE *335*

ATA CODE PID 164 FMI 1

Injection Control Pressure Unable To Build Pressure During Cranking

Flash code 335 will set if the ECM determines incorrect injection control pressure is being developed during engine cranking. It is an ICP system check and will be set after 8 to 10 seconds of engine cranking time with less than 725 psi (5 MPA) of injection control pressure detected. The period of engine cranking time before fault code 335 is set varies with engine temperature.

Engine cranking speed must be greater than 130 RPM before fault detection begins.

An active code 335 is normally associated with a long time to start or no start engine condition.

Possible Causes:

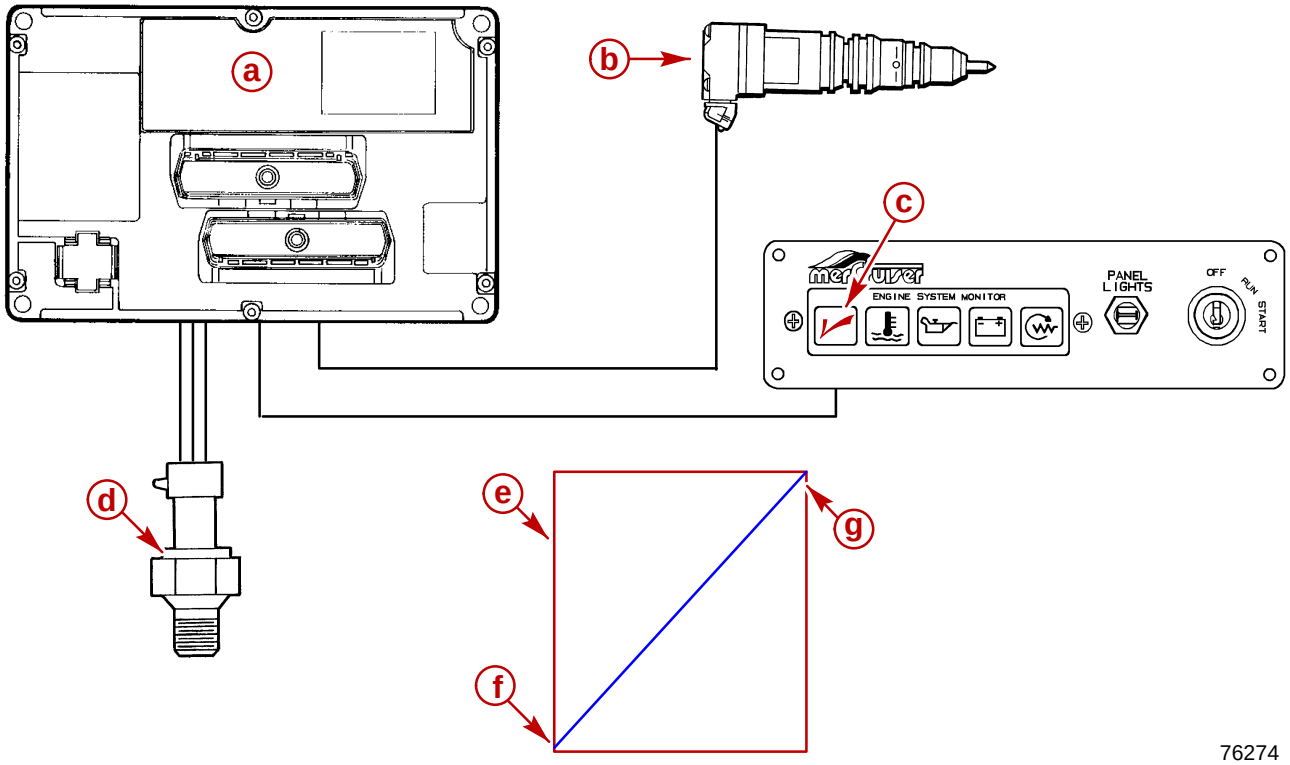
- No or insufficient oil in the engine.
- Air in the injection control pressure system (particularly after an injector or high pressure pump replacement).
- Defective or stuck injection pressure regulator.
- Leaking injector “O” rings.
- Loose high pressure pump gear.
- Defective high pressure pump.

Refer to the following table for the recommended actions for a flash code 335.

☞ **Recommended Actions:**

Test	Comments
Visual Inspection	Check to see if IPR regulator and ICP sensor wiring is connected, check for oil leaks, check to see if injection control system recently disassembled (air entrapment), assure vehicle is operated a minimum of 15 to 20 miles if symptom is hard start and evidence of recent disassembly of injection control system.
Check oil level,quality pressure	Check for level and contamination, check for oil in the oil reservoir, verify lube oil pressure during engine cranking.
Check active and inactive faults	Repair any ICP and CMP sensor codes first
Perform a Key ON Engine OFF Standard Test	Test will verify IPR valve circuit continuity
Perform Engine Running wiggle test – *Intermittent fault detection test - Hard Start Only*	When engine is running enable test, pull/ wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If fault is set or engine dies inspect wires at point of connection, check codes.
Perform ICP Pressure test – No Hard/No Start Diagnostic procedures	Will verify if oil is aerated at high idle.
Test high pressure (injection control pressure system) for leaks	Refer to ICP Leakage Tests.

MAP - Manifold Absolute Pressure Sensor



a - ECM
b - Fuel Quantity and Timing Control (Injectors)
c - Check Engine Lamp
d - MAP Sensor
e - Map Signal (Analog Voltage) Chart
f - 0 Volts (Less Boost Pressure)
g - 5 Volts (More Boost Pressure)

SIGNAL FUNCTIONS

The Manifold Absolute Pressure (MAP) sensor is a variable capacitance sensor which operates on a 5 volt reference signal from the ECM to produce a linear analog voltage signal that indicates pressure.

Smoke Control - The MAP signal is used to control smoke by limiting fuel quantity during acceleration until a specified boost pressure is obtained.

Dynamic Injection Timing - Optimizes injection timing for boost pressure measured.

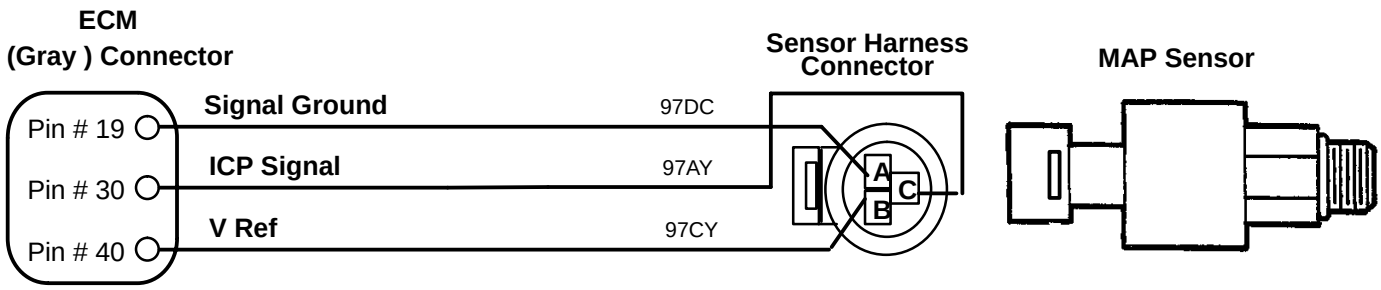
FAULT DETECTION / MANAGEMENT

A MAP signal that is detected by the ECM to be out of range or at an incorrect value for specific conditions will cause the ECM to ignore the MAP signal and will operate the engine with the values from estimated MAP (a program of default boost pressure signal values).

MAP - Manifold Absolute Pressure Sensor (Continued)

Manifold Absolute Pressure Sensor (MAP)

Fault Codes:
121 Signal Freq. High/Low
122 Signal Freq. Low/Inactive
123 In range Fault



NOTE: *After removing connectors always check for damaged pins, corrosion, loose terminals, etc.*

Connector Voltage Checks
(Check with sensor connector disconnected and Ignition Key in RUN position)

Test Points	Spec.	Comments
A to Grd.	0–.25 volts	If greater than .25 volts, signal ground is shorted to V Ref or battery.
B to Grd.	5 volts ± .5	V Ref check with key ON, if voltage not in spec., see V Ref circuit
C to Grd.	0–.25 volts	If greater than .25 volts, signal ground is shorted to V Ref or battery.

Connector Checks to Chassis Ground
(Check with sensor connector disconnected, positive battery cable disconnected and Ignition key OFF)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground, check with key off, if greater than 5 ohms the harness is open.
B to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#19 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector – Signal ground
#40 to B	< 5 ohms	Resistance from sensor connector to 60 pin connector – V Ref
#30 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector – MAP signal

Test Points (+) #30 to (–) #19		**Operational Voltage Checks (Check with breakout box installed in line with the ECM)**	
Voltage	PSI	kPAG	Comments
.039 v	N/A	N/A	Out of range low limit.
0.92 v	0	0	Voltage with key in RUN position and engine off. Atmospheric pressure dependent on altitude and BARO pressure.
1.73 v	8.0	56	
2.72 v	18.0	124	

Fault Code Descriptions

Circuit Faults:
121 = Signal voltage was greater than 4.9 volts for more than 0.1 seconds.
122 = Signal voltage was less than .039 volts for more than 0.1 seconds.

System Faults:
123 = Detected high boost (above 16.7 psi/115 kPA) signal at low idle.

MAP - Manifold Absolute Pressure Sensor (Continued)

FUNCTION

The engine control system includes a Manifold Absolute Pressure (MAP) sensor. The ECM measures the signal from the MAP sensor to determine intake manifold (boost) pressure. From this information, the ECM can optimize control of fuel rate and injection timing for all engine operating conditions.

OPERATION

The Manifold Absolute Pressure sensor is a variable capacitance sensor located on the intake manifold that produces a linear analog voltage signal output. The MAP sensor is supplied 5 volts from ECM pin 19 to terminal A of the sensor. A return circuit (ground) is supplied from ECM pin 40 to terminal B of the sensor. Pressure applied to the MAP sensor changes the capacitance of the sensor which varies the signal voltage sent to the ECM. As boost pressure increases, the voltage signal increases.

ECM DIAGNOSTICS

The ECM monitors the MAP sensor output signal for expected values. If the ECM detects the MAP signal is greater than or less than the desired value, the ECM will set a fault code.

If an active MAP sensor fault code is set, the ECM will ignore the MAP signal. It will operate the engine using programmed default values. Active faults for the MAP sensor will cause the ECM to illuminate the Check Engine lamp. These faults can be retrieved using the Audio Test switch to initiate a Self Test Input diagnostic test or the Electronic Service Tool. If the ignition key is turned off, the fault code will be stored as an Inactive code.

FLASH CODE *121*

ATA CODE PID 102 FMI 8

MAP Frequency Out Of Range High

Code 121 will be set, if the ECM detects a MAP signal voltage greater than 4.9v for more than 0.1 seconds.

If code 121 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Check Engine lamp when this code is active.

MAP - Manifold Absolute Pressure Sensor (Continued)

FLASH CODE *122*

ATA CODE PID 102 FMI 11

MAP Signal Is Out Of Range Low

Code 122 will be set, if the ECM detects a MAP signal voltage less than .039v for more than 0.1 seconds.

When code 122 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Check Engine lamp when this code is set.

Possible causes include:

- A defective MAP sensor.
- MAP sensor signal circuits may be open or shorted to ground.

FLASH CODE *123*

ATA CODE PID 102 FMI 2

MAP Signal Above Specified Level At Low Idle

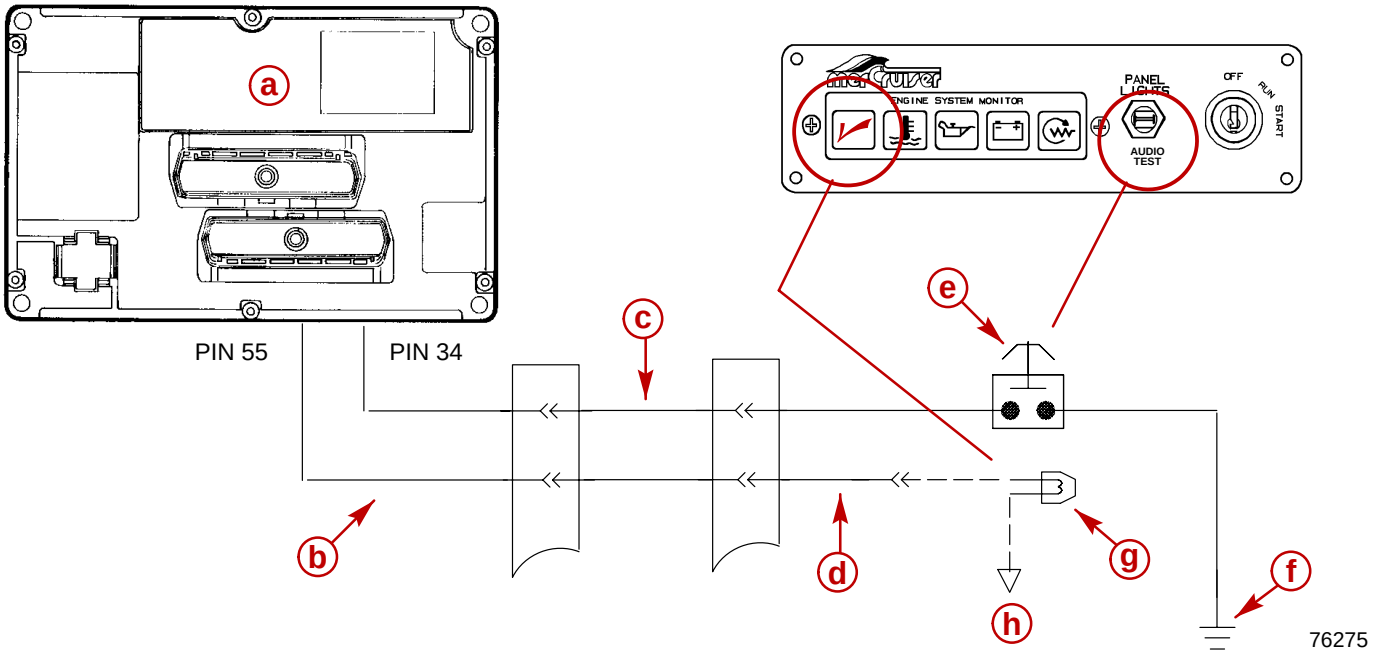
Code 123 is set when the MAP signal is greater than 16.7 PSI (115 kPa) Absolute at low idle.

When code 123 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Check Engine lamp when this code is set.

Possible causes include:

- Restricted or plugged MAP sensor inlet.
- Defective MAP sensor.

STI - Self Test Input Test & Check Engine Lamp



a - ECM
b - Engine Harness
c - Extension Harness
d - Instrumentation Harness
e - Audio Test (STI) Switch
f - Ground (–)
g - Check Engine Lamp
h - Ignition Voltage

SIGNAL FUNCTIONS

The Audio Test switch can be used to initiate a Self Test Input (STI) diagnostic test. The switch (or Prolink EST) can be used to run the Key On Engine Off (KOEO) Standard Tests. Faults detected during this test result in active fault codes, which are transmitted as FLASH codes with the Check Engine Lamp. If no faults are detected, the ECM will FLASH code 111 (indicates no faults detected).

ECM pin 34 has 12 volts with the key in the RUN (ON) position and engine “OFF”. Pressing down and holding the Audio Test (STI) switch while simultaneously turning the Ignition Key to RUN (but not starting the engine) grounds pin 34, causing it to change from 12 volts to 0 volts, signaling the ECM to start the KOEO Standard Tests.

CHECK ENGINE LAMP

Pressing down and holding the Audio Test (STI) switch, while simultaneously turning the key switch to RUN, illuminates the Check Engine lamp, which stays ON while the ECM runs normal startup tests. Normally, the Check Engine lamp then turns OFF after the tests is complete. If the ECM detects a problem, the Check Engine lamp remains ON.

Ignition power is applied to the Check Engine lamp. The ground side of the lamp is connected to ECM terminal 55, which is a ground switch. The ECM applies 5 volts to the ground switch of ECM pin terminal 55 (lamp stays OFF) or 0 volts (lamp goes ON), in response to engine conditions.

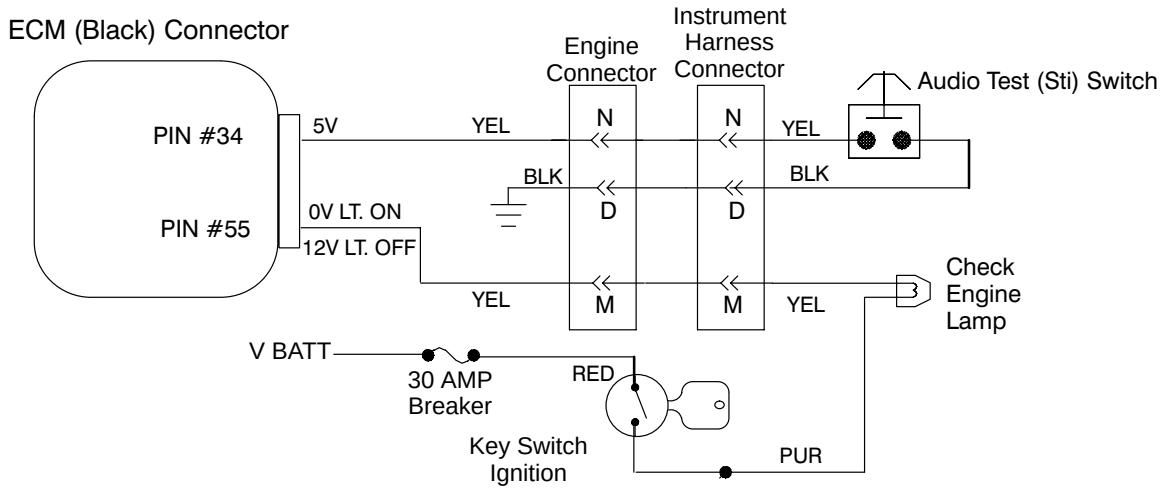
FAULT DETECTION MANAGEMENT

There are no ECM diagnostics for the STI or Warning light circuits.

STI - Self Test Input Test & Check Engine Lamp (Continued)

Self Test Input (STI) / Check Engine Lamp

Fault Codes:
No Diagnostic Codes for these Systems



Test STI switch with ignition key "OFF"

Test Points	Spec.	Comments
Across Switch Terminals	> 1000ohms open position	< than 1000 ohms replace switch
Across Switch Terminals	< 5 ohms closed position	> than 5 ohms replace switch

Test at Audio Test (STI) switch connection with ignition key "OFF"

Test Points	Spec.	Comments
BLK to grd.	> 1000 ohms	< than 1000 ohms locate short to ground

Test at Audio Test (STI) switch connection with ignition key in RUN position.

Test Points	Spec.	Comments
YEL to grd.	5 ± .5 volts	< than 4.5v check connections, if 0 volts, check for open/short to ground in ckt. 98
YEL to BLK	5 ± .5 volts	< than 4.5v check connections, if 0 volts, check for open in ground circuit.

IF Check Engine lamp does not turn on when key is turned to RUN (ON) :

1. Check breaker and bulb condition.
2. Disconnect black 60-way connector from ECM and install breakout box to harness. Jumper terminal 55 to ground and note if light is ON.
   - A. If light is ON, the ECM is defective.
   - B. If light does not turn ON, check circuit for open condition.
   - C. If light goes OFF, ECM is defective.

IF Check Engine lamp stays ON after Self Test :

1. Check for active fault conditions (use EST or STI flash codes)
   - A. If active fault conditions are present correct faults.
   - B. If no fault conditions are present, go to step 2.
2. Disconnect black 60-way connector from ECM and note if LIGHT remains ON.
   - A. If light remains ON, check for short to ground in circuit.

Fault Code Descriptions

266 = Output Circuit Check detected during Standard Test, indicates high or low resistance in Check Engine Lamp circuit.

STI - Self Test Input Test & Check Engine Lamp (Continued)

Refer to circuit diagram for the following discussion.

AUDIO TEST / STI SWITCH

The Audio Test (STI) switch (or Prolink EST) can be used to initiate the Key On Engine Off (KOEO) Standard Tests. Faults detected during this test result in active fault codes, which are transmitted as FLASH codes with the Check Engine lamp. If no faults are detected, the ECM will FLASH code 111 (indicates no faults detected).

Depressing and holding the Audio Test (STI) switch while simultaneously turning the key to the RUN (ON) position and engine OFF starts the test cycle. The KOEO Standard tests include: (1) ECM Internal Tests and (2) Output Circuit Check (OCC) tests.

The normally open (N.O.) switch has one pole connected through the circuit and ECM black connector to the ECM's STI pin 34. The other switch pole is connected to the engine ground stud (T2).

ECM pin 34 has 5 volts with the key in RUN and engine OFF. Depressing and holding the Audio Test (STI) switch while simultaneously turning the key to the RUN (ON) position grounds pin 34, causing it to change from 5 volts to 0 volts, signaling the ECM to start the KOEO Standard Tests.

CHECK ENGINE LAMP

When the key switch is turned to RUN (ON), the Check Engine lamp turns ON and stays ON, while the ECM runs normal startup tests, and then turns OFF. If the ECM detects a problem, the Check Engine lamp remains on.

Refer to circuit diagram for the following discussion.

Ignition power on PUR wire is applied to the Check Engine lamp. The ground side of the bulb is connected to ECM pin 55, which is a ground switch. The ECM applies 12 volts to ECM pin 55 (light OFF) or 0 volts (light ON), in response to engine conditions.

ECM DIAGNOSTICS

There are no ECM diagnostics for the STI or Warning Light circuits.

STI - Self Test Input Test & Check Engine Lamp (Continued)

TROUBLESHOOTING SELF TEST INPUT (STI) SWITCH

If depressing the STI switch with key on and engine off does not cause the OCC tests to run (if no faults are detected code 111 should flash), perform Testing The STI Circuit.

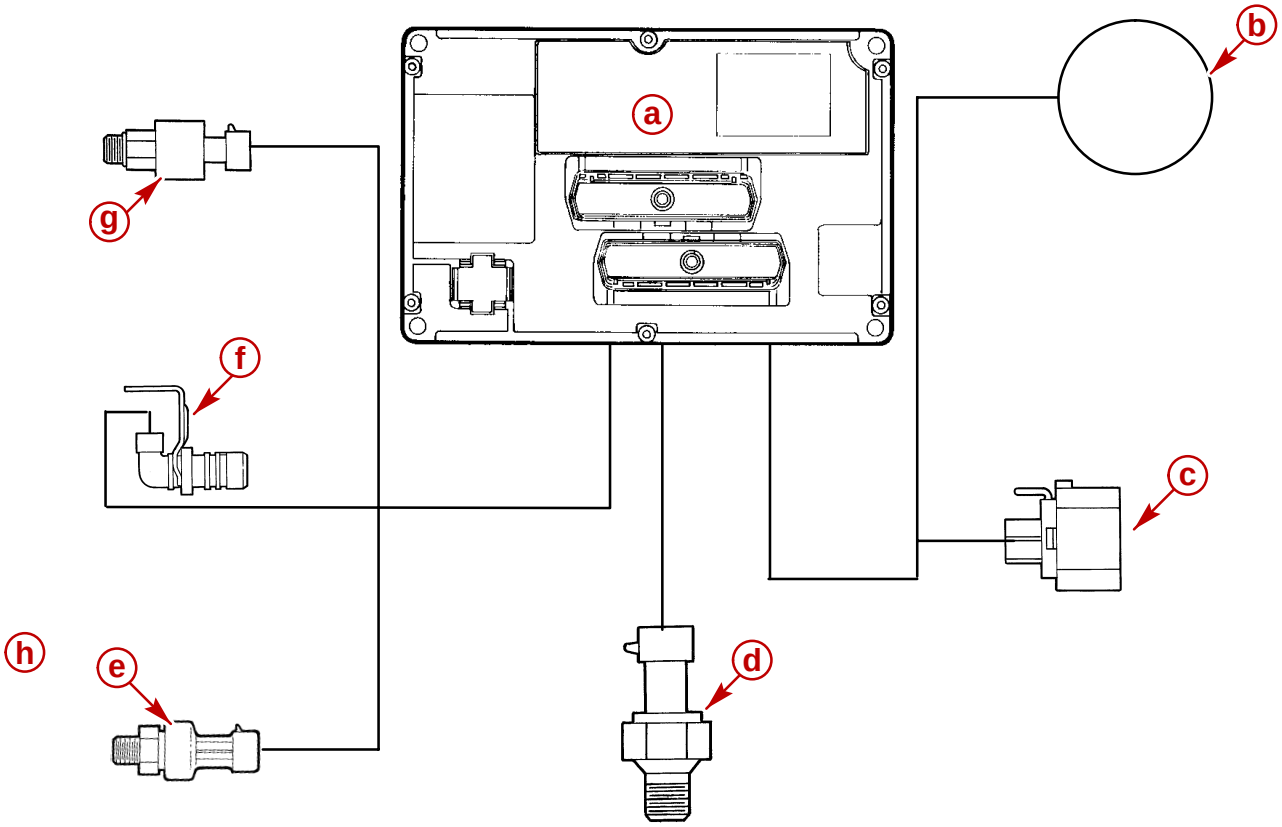
CHECK ENGINE LAMP MALFUNCTION

If depressing and holding the Audio Test (STI) switch while simultaneously turning the key to the RUN (ON) position with engine OFF, does not turn ON the Check Engine lamp during the ECM startup tests, or if the lamp stays ON after the engine is running with NO ACTIVE FLASH CODES, perform Check Engine Lamp Does Not Turn ON test or Engine Check Lamp Stays ON test.

BEFORE TROUBLESHOOTING

1. Before troubleshooting, make sure that the batteries are fully charged! Check battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading results if the batteries are not fully charged.
2. Before troubleshooting, inspect circuit connectors for pushed back, loose, or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
3. Before troubleshooting, inspect suspect circuit grounds for clean, tight connections free of damage.

V Ref - Voltage Reference Circuits



EG–1255

V Ref Function Diagram

- **a** - ECM
- **b** - APS/IVS
- **c** - BARO
- **d** - MAP
- **e** - EOP
- **f** - CMP
- **g** - ICP

CIRCUIT FUNCTIONS

The V Ref circuit is a 5 ± .5 volt power supply from the ECM that provides power to the three wire engine and vessel sensors and provides a benchmark or reference voltage for the ECM.

FAULT DETECTION/MANAGEMENT

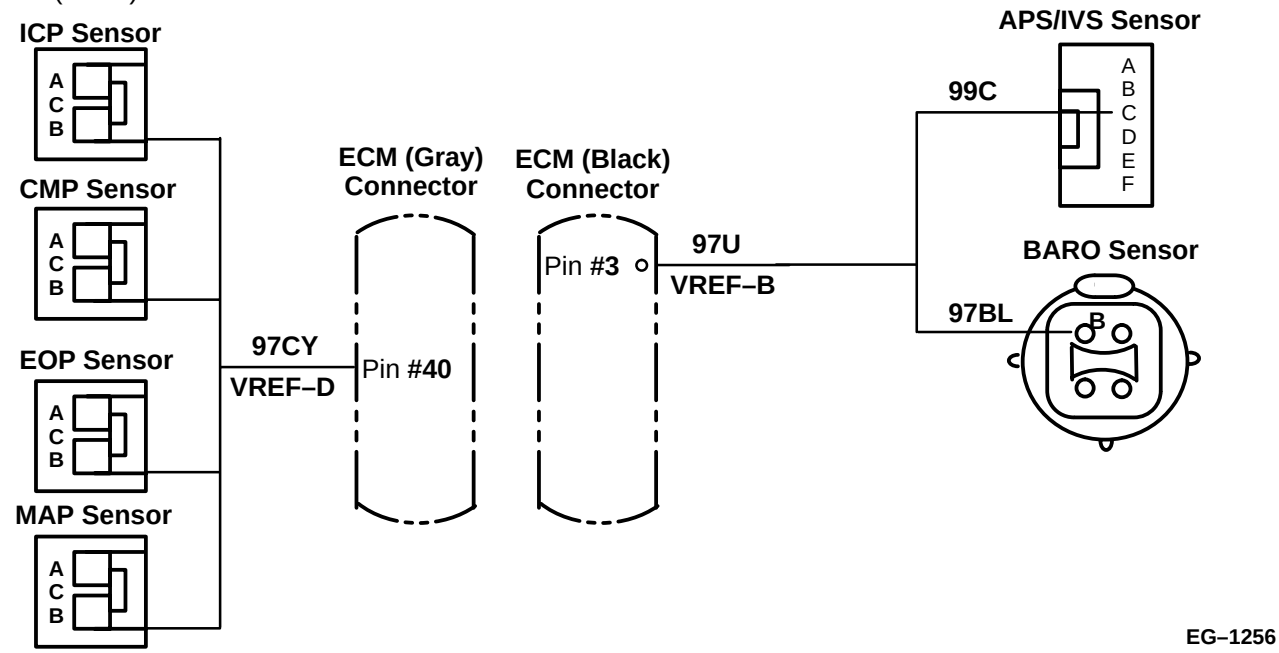
There is no fault detection specifically for the V Ref signal directly, but if there is a V Ref circuit fault the sensor(s) in the section of the circuit affected may set an out of range high or low code.

IMPORTANT: Multiple high or low codes are usually an indication of a V Ref or in some instances a Signal Ground fault condition.

V Ref - Voltage Reference Circuits (Continued)

Voltage Reference Circuits (V Ref)

Fault Codes:
Multiple out of range high/low faults set.
(Dependent upon where open or short is located.)



EG–1256

Connector V Ref Voltage Checks

(If multiple faults set remove and measure V Ref at suspected sensor circuits)

Sensor	Test Points	Spec.	Comments
ICP	B to Grd.	5 ± .5 v	Check V Ref at suspected sensors one at a time. Identifying which sensors do not have V Ref and which ones share common V Ref feed will more quickly help isolate the area of a short or open circuit. If disconnecting a sensor causes V Ref to be present at a ckt. that had previously lost V Ref, it is likely that the disconnected sensor had shorted V Ref to ground.
CMP	B to Grd.	5 ± .5 v	
MAP	B to Grd.	5 ± .5 v	
APS/IVS	C to Grd.	5 ± .5 v	
BARO	B to Grd.	5 ± .5 v	

Connector Checks to Chassis Ground

(Check with sensor connector(s) disconnected and Ignition key OFF, all accessories OFF.

Sensor	Test Points	Spec.	Comments
ICP	B to Grd.	> 1000 ohms	Resistance < 1000 ohms indicates a short to grd. If a short to grd condition is identified– ed, remove all sensor connectors that are connected to V Ref and ECM to determine if short is in a sensor, ECM or wire harness. If the short is identified in the harness, re– move the intermediate Deutsch connectors and measuring to grd. will identify which part of the harness the short is located in.
CMP	B to Grd.	> 1000 ohms	
MAP	B to Grd.	> 1000 ohms	
APS/IVS	C to Grd.	> 1000 ohms	
BARO	B to Grd.	> 1000 ohms	

Connector Checks to Chassis Ground

(Check with sensor connector(s) disconnected and Ignition key OFF, all accessories OFF)

Sensor	Test Points	Spec.	Comments
ICP	B to #19	< 5 ohms	The measurement is taken from the sensor connector to the ECM 60 pin connector. Resistance greater than 5 ohms indicates high resistance or an open in the V Ref supply circuit.
CMP	B to #19	< 5 ohms	
MAP	B to #19	< 5 ohms	
APS/IVS	C to Grd.	< 5 ohms	
BARO	B to Grd.	< 5 ohms	

V Ref - Voltage Reference Circuits - (Continued)

FUNCTION

The Electronic Control Module contains a regulated 5 volt DC voltage reference source to power engine sensors. The sensor signals are compared to the Voltage Reference to determine actual sensor output signal values. These values are processed by the ECM for engine operation.

OPERATION

The ECM is supplied with Battery Voltage when the ignition key is ON at terminal 40 (gray connector) for the engine and terminal #3 (black connector) for the remaining vessel connections.

ECM VOLTAGE REFERENCE DIAGNOSTICS

If multiple sensor codes are set, it is possible that the V REF signal circuit is open or the return signal circuit is open. Follow troubleshooting procedures to determine if V REF circuits are at fault. The engine will not run without a valid V REF signal.

FUEL SYSTEM

Section 5D - Diagnostic Tool Use

Table of Contents

Special Tools 5D-2
Mercury MerCruiser 5D-2
Additional Special Tools and/or Suppliers 5D-3
Diagnostic Tools 5D-4
Beyers Model 200 Pressure Test Kit . . . 5D-4
Dwyer Slack Tube Manometer 5D-5
Orificed Restrictor Tool and Adapter . . 5D-7
Glow Plug/Injector Breakout 5D-8
ICP/EBP Breakout “T” 5D-8
High Pressure Leakage Test Tool/Adapters 5D-9
Fluke 88 Digital Multimeter 5D-9
Breakout Box 5D-10
Electronic Service Tool (EST) - Pro-Link 9000 . . . . . 5D-11

5 D

Special Tools

Mercury MerCruiser

DESCRIPTION	SUPPLIER P/N	MERCURY P/N
Cylinder head lifting bracket	ZTSE4297	
Compression gauge	ZTSE2482A	
Compression gauge adapter	ZTSE4292	
Valve spring tester	ZTSE2241	
Valve spring compressor	ZTSE4298	
Injector sleeve remover	ZTSE4302	
Injector/front seal removal	ZTSE4300	
Injector sleeve installer	ZTSE4303	
Injector tip brush	ZTSE4301	
Injector sleeve brushes	ZTSE4304	
Injector sleeve seat brush	ZTSE4305	
Cylinder head coolant plate	ZTSE4308	
Cylinder head bolt bottom tap	ZTSE43862	
Injector holder rack and caps	ZTSE4299	
Cleaning brush set	ZTSE4320	
Injector remover	ZTSE4354	91-854264
Injector installer	ZTSE4353	91-854265
Damper wear ring remover	ZTSE4314	
Damper wear ring installer	ZTSE4315	
Damper and front seal installer	ZTSE-4310	
Hydraulic valve lifter tester	ZTSE-1893	
Flex hone	ZTSE4349	
“Plasti-gage”	D81L6002B	
Crankcase cup plug installer	ZTSE4309	
Rod guide caps	ZTSE4311	
Camshaft bushing tools	ZTSE2393C	
Keystone pin gauges	ZTSE30201	
Front crankshaft oil seal installer	ZTSE4310	
Crankshaft wear ring remover	ZTSE4317	
Crankshaft wear ring installer	ZTSE4318	
Engine harness repair kit	ZTSE4291	

Mercury MerCruiser (Continued)

High pressure oil system cap set	ZTSE4295	
Fuel system cap set	ZTSE4294	
Fluke 88 digital multimeter		
Injection control pressure high pressure leak test tool	EG-132	91-854266
Glow plug/injector “T” harness	ZTSE-4345	91-854267
Pressure test kit box	ZTSE-2239	91-854268
Injection control pressure(ICP) “T” harness	ZTSE-4347	91-854269
Crankcase orifice restrictor and adapter	ZTSE-4146-A ZTSE-4284	91-854270 91-854271
Exhaust back pressure sensor “T” harness	ZTSE-4347	
Break out box	ZTSE-4346	91-854272
Rinda diagnostic tool	94050M	
Electronic diagnostic tool kit includes : • Prolink 9000 • Cartridge • Adapter Cable • Data Cable	• ZTSE-43661 • ZTSE-43667 • ZTSE-436633A • ZTSE-501003	91-854273

Additional Special Tools and/or Suppliers

PROLINK:
OTC Division, SPX Corp
655 Eisenhower Drive
Owatonna, Minnesota 55060
Ph: 507-455-7244
Fax: 800-283-8665

RINDA:
Rinda Technologies Inc.
4563 Elston Avenue
Chicago, Illinois 60630
Ph: 773-736-6633
Fax: 773-736-2950

MPE:
Marine Power Europe, Inc.
Parc industriel de Petit-Rechain
4800 Verviers - Belgium
Ph: 32(87)32.32.11
Fax: 32(87)31.19.65

Diagnostic Tools

Beyers Model 200 Pressure Test Kit (ZTSE-2239)

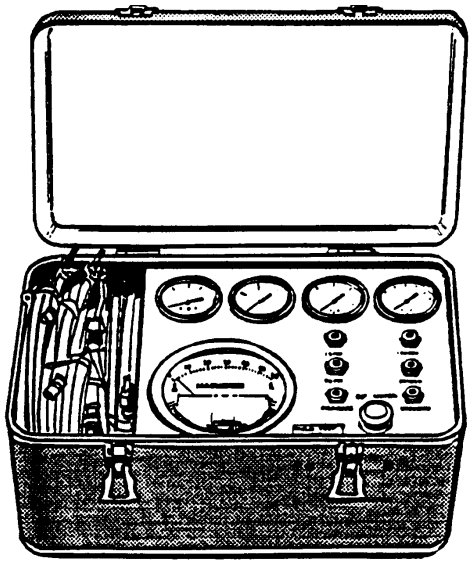
DESCRIPTION

The Pressure Test Kit can be used to measure intake manifold (Boost) pressure, fuel pressure, air cleaner restriction, fuel restriction, exhaust back pressure and crankcase pressure. It may also be used to test the accuracy of the gauges within the kit.

The 0-30 psi gauge may be used to measure fuel pressure or intake manifold (Boost) pressure.

The 0-30 in. Hg. vacuum gauge (0-14.7 psi) is used to measure fuel system inlet restriction.

The 0-60 inches of water (magnehelic) gauge (0 2.16 psi) may be used to measure air cleaner restriction or crankcase pressure.



Pressure Test Kit Model D-200 (ZTSE-2239)

⚠ CAUTION

The quick disconnects have shut-off valves in the panel connectors not in the plug. DO NOT connect or disconnect lines while under pressure.

NOTE: *When using the magnehelic gauge, be sure to plug the test line into the proper ("Pressure" or "Vacuum") port. Use the "Pressure" port to read exhaust back pressure and crankcase pressure. Use "Vacuum" port to read air cleaner restriction. In both cases, THE OPPOSITE CONNECTOR MUST BE VENTED TO THE ATMOSPHERE BY INSTALLING A QUICK CONNECTIVE PLUG IN THE PORT.*

The 0-160 psi gauge may be used to check fuel pressure.

The 0-300 psi gauge is not normally used for any engine diagnostic check.

Beyers Model 200 Pressure Test Kit (Continued)

MAINTENANCE AND GAUGE ACCURACY TEST

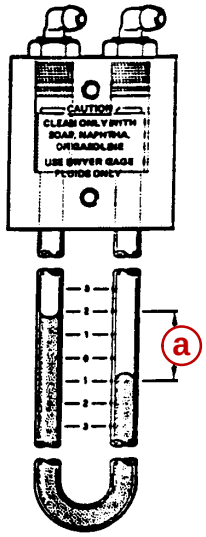
1. Remove cover of pressure test kit and inspect for damage to gauges such as broken cover glass, bent gauge needles, and for missing pressure connectors and nylon tubing. Replace damaged or missing parts so that the kit will operate when needed.
2. Remove the screws holding the gauge panel to carrying case and lift the panel from the carrying case. If any liquids are found in the tubing behind the panel, loosen the connections and blow out the liquids. Tighten all connectors as required and reassemble the gauge panel.
3. The hand operated pump is directly connected to 0-30 psi gauge when the kit is received. If a gauge accuracy test is desired, proceed as described under CALIBRATING THE PRESSURE KIT using the Dwyer Slack Tube Manometer, in this section.

OPERATING INSTRUCTIONS

Connect tubes between the test ports on the panel and the test points.

Dwyer Slack Tube Manometer

DESCRIPTION



Slack Tube Manometer (Dwyer No. 1211-48)

a - Dimension Indicates Total Fluid Column

The manometer is a U-shaped tube with a scale mounted between the legs of the “U”. Where the portability of the Model 200 Pressure Test Kit is not required, this manometer can be used to measure either low pressure or vacuum and may be filled with water.

Order from:

Dwyer Instruments, Inc.
P.O. Box 373
Michigan City, Indiana 46360
Phone: (219) 872-9141

Dwyer Slack Tube Manometer (Continued)

FILLING

The manometer may be filled with water, when checking very low pressures.

When filling with water, use only good drinking water without additives except for some colored water vegetable dye which enables the tester to read the scale easier. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

IMPORTANT: Never use an antifreeze solution, soda pop, tonic, etc. the increase in density causes false readings.

INSTALLING AND READING

1. Support the manometer in a vertical position. Be sure the fluid is at the zero mark on the scale.
2. Connect one leg of the manometer to the source of the pressure or vacuum. Be sure the other leg is open to atmosphere.
3. Start the engine and when the engine is in the proper operating condition as specified, observe the manometer.
4. After about two minutes, record the average position the fluid level is above and below the zero mark. Add the two figures together. The sum of the two is the total column of fluid.

NOTE: *At times both columns of the manometer will not travel the same distance. This is of no concern to the tester as long as the leg not connected to the pressure or vacuum source is open to the atmosphere.*

CLEANING

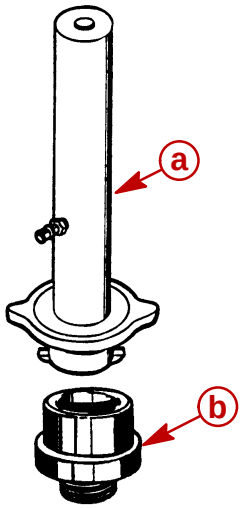
1. Wash the tube thoroughly with a little pure soap and water. Avoid liquid soaps and solvents.

Orificed Restrictor Tool (ZTSE-4146A) and Adapter (ZTSE-4284)

DESCRIPTION

This Orificed Restrictor tool (ZTSE-4146A) in conjunction with the Restrictor Adapter (ZTSE-4284) are used to measure combustion gas flow out of the engine. The Orificed Restrictor contains an integral oil fill cap which provides nearly effortless set-up when performing a crankcase pressure test on the Diesel Engine. The Model D-200 Pressure Test Kit and a plastic cap are also required to perform the crankcase pressure test.

IMPORTANT: Pressure readings obtained with this restrictor must not be used as the main source of engine condition. Oil consumption trend data must also be used if the pressure readings are beyond the specified limits. Neither changes in oil consumption trends nor crankcase diagnostic pressure trends can establish a specific component problem but are only indicators that some problem exists.



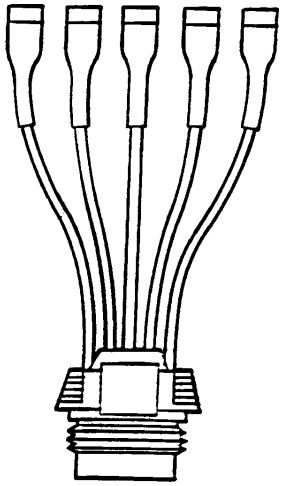
Crankcase Pressure Diagnostic Tools

a - Orificed Restrictor Tool (ZTSE-4146A)
b - Crankcase Restrictor Adapter (ZTSE-4284)

Glow Plug / Injector Breakout (ZTSE-4345)

DESCRIPTION

The Glow Plug/Injector breakout tool (ZTSE-4345) is used to check injector solenoid continuity and glow plug resistance to ground. Use of this tool is shown in Mechanical Diagnostics SECTION 5B.



Glow Plug / Injector Breakout (ZTSE-4345)

ICP / EBP Breakout “T” (ZTSE-4347)

DESCRIPTION

ICP Injection Control Pressure / Exhaust Back Pressure Sensor Breakout “T” (ZTSE-4347) is used to gain access to Injection Control Pressure, and Exhaust Back Pressure signal (not employed on MerCruiser products) voltages. The “T” enables the technician to quickly connect a voltmeter to read voltage (pressure) signals at each of the sensors. Use of the “T” to measure Injection Control Pressure is shown in Mechanical Diagnostics SECTION 5B.

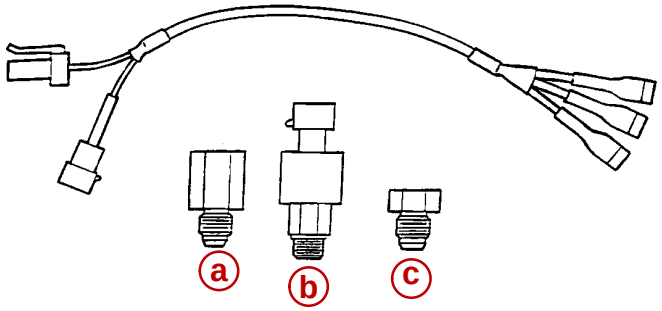
ICP / EBP Breakout “T” (ZTSE-4347)

NOTE: *Exhaust Back Pressure (EBP) Sensor and related components are not present on these marine engines.*

High Pressure Leakage Test Tool / Adapters

DESCRIPTION

The ICP / EBP breakout “T”, adapter, plug and ICP sensor are used to perform High Pressure Leakage Tests on the Injection Control Pressure system. Refer to High Pressure Leakage Tests in Mechanical Diagnostics SECTION 5B for use of these tools/adapters.



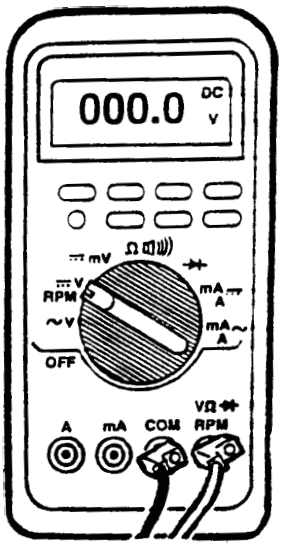
High Pressure Leakage Test Tools

a - Adapter
b - ICP Sensor
c - Plug

Fluke 88 Digital Multimeter

DESCRIPTION

The Fluke 88 multimeter allows the technician to troubleshoot the electrical components (sensors, injector solenoids, relays, wiring harnesses, etc.) associated with the MCM 7.3L D-Tronic. In addition, it measures engine RPM. This feature allows the technician to measure engine cranking RPM when the Electronic Service Tool (EST) is not available or is unable to receive ATA data. This meter has a high input impedance which allows testing of sensors while the engine is running, without loading the circuit which is being tested. This ensures the signal voltage measurement will not be affected by the voltmeter.

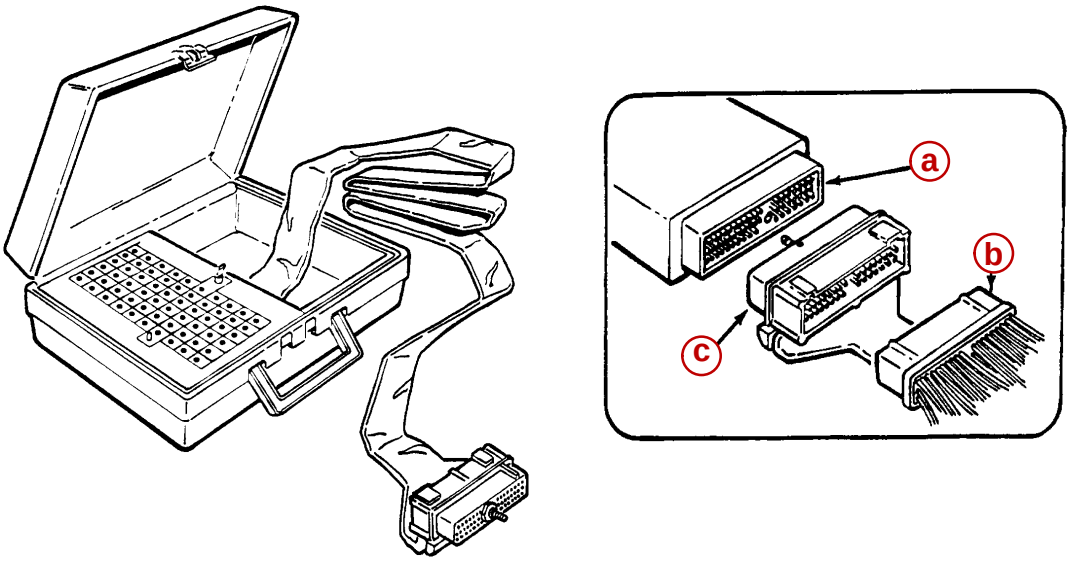


Fluke 88 Digital Multimeter

Breakout Box (ZTSE-4346)

Breakout Box (ZTSE-4346) was designed to allow testing of the electrical system with the ECM hooked up and in the system. This will allow ECM input and output measurement with the components operating.

It should be noted that the Breakout Box should be used for measurement only, and not to activate or control circuits. High current levels passing through the breakout box will burn out internal circuitry.



Breakout Box (ZTSE-4346)

- **a -** Engine Microprocessor (ECM)
- **b -** Engine Harness
- **c -** Breakout Box Connector

BREAKOUT BOX INSTALLATION

1. Remove the weather cover at the engine cowl located on the upper driver's side of vessel.
2. Remove the 60 way connector from the ECM. Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter to the ECM.
3. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.

Readings can now be taken at the test connections in the breakout box. The numbers at the test connections correspond to the ECM terminal numbers.

DESCRIPTION

Fault codes can be detected and stored in the ECM (Electronic Control Module).

The EST (Electronic Service Tool) is used to access stored fault codes by plugging it into the ATA (American Trucking Association) data link connector.

Electronic Service Tool (EST) - Pro-Link 9000 (ZTSE-43661)

DESCRIPTION

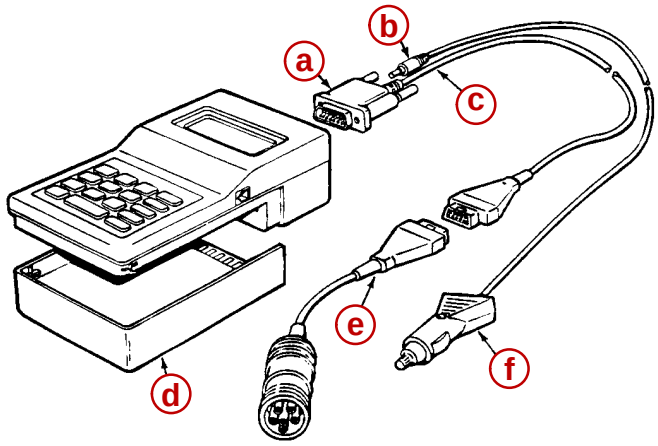
The PRO-LINK 9000 (ZTSE-43661) Electronic Service Tool (EST) “communicates” with the engine control system through the connectors as shown. The EST communicates with the ECM using the American Trucking Association (ATA) data link lines.

All communication between the EST and the engine control system is done through the EST connectors. This tool is capable of:

- Displaying fault codes and operating conditions.
- Performing proprietary diagnostic tests programmed into the cartridge.
- Clearing fault codes.

Features include:

- Data Readout Window
- Soft Touch Keypad
- Data and Power Cable Connector
- RS232 Serial Data Port
- Push button



Electronic Service Tool Pro-Link 9000 (ZTSE-43661)

a - 15 Pin Vehicle Cable
b - Power Cable
c - Data Cable
d - Data Cartridge (Specific cartridge for each application)
e - Adapter
f - Power Cable (Not needed for some applications)

Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

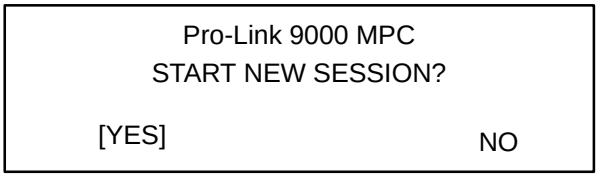
DIAGNOSTIC CODE RETRIEVAL

Turn all accessories and the ignition off. Connect the EST tool to the ATA diagnostic connector. The screen of the reader should light up as soon as the tool is plugged in.

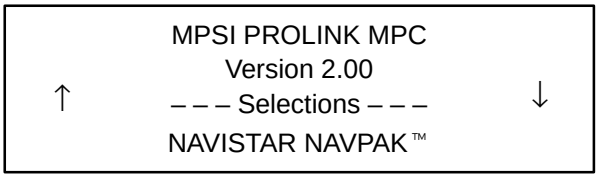
Turn the key switch (ignition switch) to the RUN (ON) position but do not start the engine. This will allow the EST to receive data from the electronic control components

If no data is received press “ENTER” to retry. The information received will be data as to the current status of the engine.

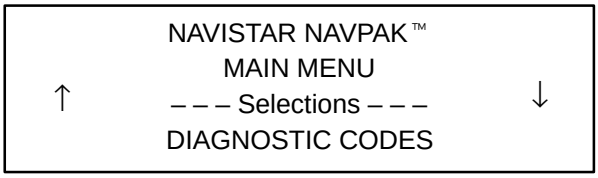
The first screen may be the following. Press the “←” key to select “YES.” To access the next menu press the “ENTER” key.



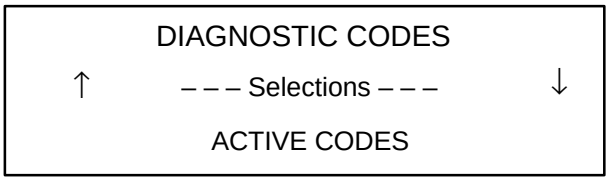
The next screen should be the following. By pressing the “↓ ↑” key the other selections will display on the screen. Select “NAVISTAR NAVPAK™.” To access the main menu press the “ENTER” key.



After the tool is finished “LOADING” the NAVPAK™ program, the first screen that will appear will be “ENGINE DATA LIST”. From the main menu press the “↓ ↑” key and selections will display on the screen. If another option was selected press “↓” key until “DIAGNOSTIC CODES” appears on the screen.



Next press “ENTER.” At this point diagnostic codes can be accessed. The first option that will appear is “ACTIVE CODES”.



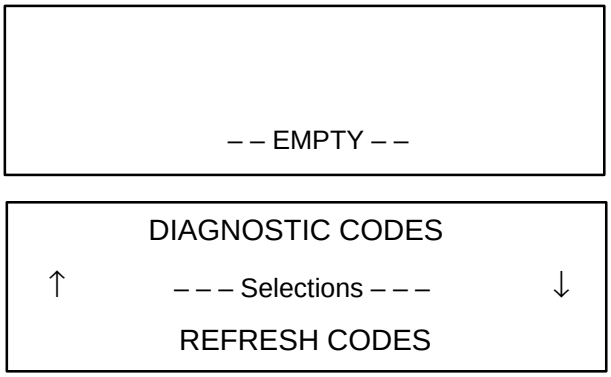
Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

ACTIVE CODES

By selecting this option, the fault codes that are currently occurring or that have occurred during the last key ON cycle will be displayed. Press “ENTER”. If there are any “Active Codes” the first one will appear on the screen along with a description of the code. If there are any additional codes “Active” the “↑↓” symbol will appear on the screen.

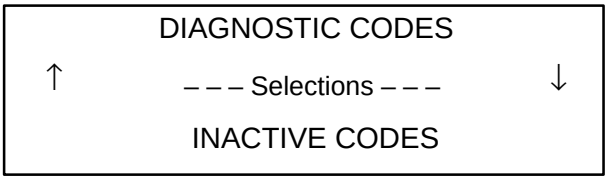
EXAMPLE:

Press “↓” key to access additional codes. If there are not any codes “Active,” “EMPTY” will appear and flash on the screen.



INACTIVE CODES

To access “Inactive Codes” press the “FUNC” key. This will access the last prior selection. Then press the “↓” key to select “INACTIVE CODES.” Press the “ENTER” key.

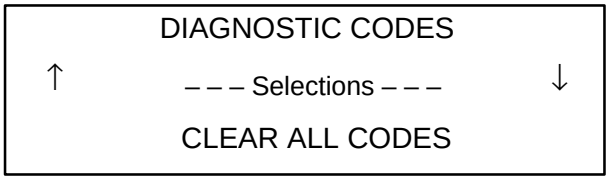


Inactive codes are faults that have occurred in the past, and are now stored in memory. An “Active Code” will become an “Inactive” code if the key is shut off or the malfunction no longer exists (such as an intermittent problem).

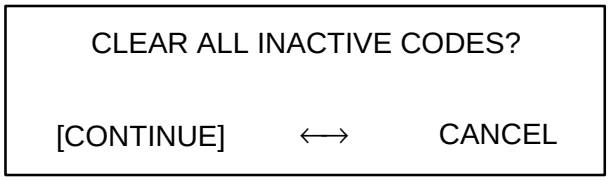
Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

CLEAR CODES

To remove the codes from the memory, the EST is equipped with a “CLEAR CODES” option. To access this option, press the “FUNC” key, this will revert back to the “DIAGNOSTIC CODES” menu. Press the “ENTER” key. Press the “↓” until “CLEAR ALL CODES” appears on the screen.



Press the “ENTER” key. The screen will ask “CLEAR ALL INACTIVE CODES?” Press the “←” key to select “YES.” Press “ENTER” and the codes will be deleted.



DIAGNOSTIC TESTS

Diagnostic tests are “Self Tests” performed by the electronic components upon demand by the operator. The “Self Tests” check various output circuits to determine if they are functioning properly.

There are two types of self tests.

1. “ENGINE OFF”
2. “ENGINE RUNNING”

“ENGINE OFF” self tests check output circuits electrically for open or short circuits with the **engine not running.**

The “ENGINE RUNNING” test, checks the outputs of engine electronic controls with the **engine running.** The effect on engine operation is measured and compared to an expected level. If **the level of operation is not within** specification, a fault is recorded.

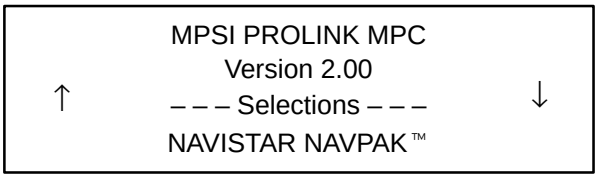
Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

ENGINE OFF TEST

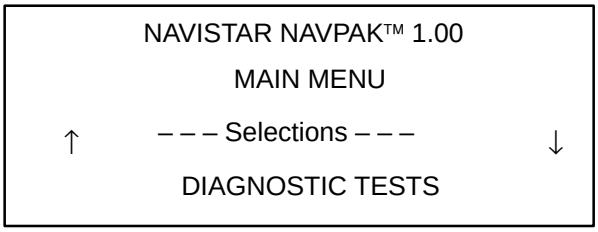
NOTE: *Access "Diagnostic Codes" menu in the EST and clear all fault codes before performing engine off tests.*

Access the "ENGINE OFF TESTS" in the "DIAGNOSTIC TESTS" section of the Electronic Service Tool (EST).

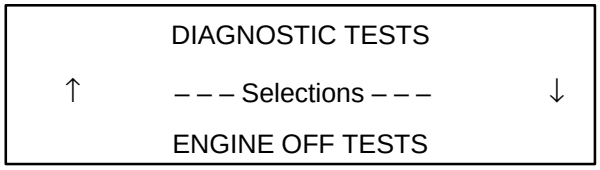
Press the "FUNC" key repeatedly, until the main menu appears on the screen. Press the "ENTER" key.



Next select the "DIAGNOSTIC TESTS" menu by pressing the "↓" key, until "DIAGNOSTIC TESTS" is shown on the screen. Press "ENTER" to make this selection.

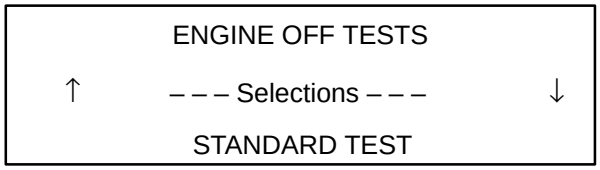


Press the "↓" key, until the "ENGINE OFF TESTS" is shown on the screen. At this point, press "ENTER."



After the "ENTER" key is pressed select the ENGINE OFF TEST you desire by using the "↓↑" keys. Select from "STANDARD TEST", "INJECTOR TEST", "WIGGLE TEST" or "OUTPUT STATE TEST." Press the "ENTER" key to perform the test selected.

EXAMPLE:



NOTE: *"STANDARD TEST" must be executed before some tests can be completed in this menu. Press "ENTER" to continue if the program states that it aborted a test. Then, select and perform the "STANDARD TEST" first.*

Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

NOTE: *If fault codes were not cleared before running ENGINE OFF TESTS, all faults and associated codes recorded during the test will be stored as "INACTIVE" codes by the EST. To read the codes, access the "INACTIVE" code menu.*

Press the "↓" key to display other options. By selecting the "STANDARD TEST" option again, the "ENGINE OFF TEST" will be repeated.

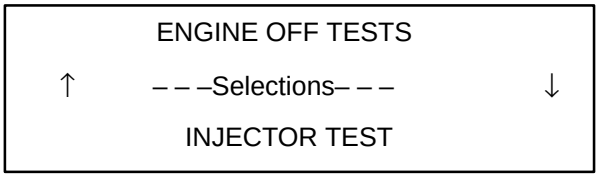
When the test is complete, the screen will display the number of faults found in the self test. If there are any additional faults found, press "ENTER" and the faults will be displayed. If there is more than one fault that was found during the test, the "↑↓" symbol will be shown on the screen. Press the "↓" key to access any additional faults. The test is repeated by selecting, "STANDARD TEST," under the "ENGINE OFF TESTS" menu, only new faults found will be displayed as "Faults Found."

INJECTOR TEST (ENGINE OFF)

NOTE: *Access "Diagnostic Codes" menu in EST and clear all fault codes.*

NOTE: *ENGINE OFF TEST - "STANDARD TEST" must be performed first in order to access the injector "Buzz" test.*

After the "ENGINE OFF TEST - STANDARD TEST" has been completed, press the "↓" key to access the "INJECTOR TEST." If the tool is not on a menu screen, i.e. displaying of fault codes etc., press the "FUNC" key. This will access the "ENGINE OFF TESTS" menu. Press the "↓" key to access the "INJECTOR TEST." Press "ENTER" to begin the test.



During this test, the injector solenoids will produce an audible clicking sound when actuated. It is possible to detect a malfunctioning injector(s) by listening for the absence of the solenoid clicking sound.

NOTE: *If fault codes were cleared before the injector "Buzz" test, fault codes displayed will be actual faults found during the test. If codes were not cleared before testing, access "inactive" fault codes from diagnostic codes menu to retrieve faults found during this test.*

At the completion of the Injector Test, any faults that have been detected will be displayed. If there is more than one fault the "↑↓" symbol will be displayed. These additional faults can be accessed by pressing the "↓" key.

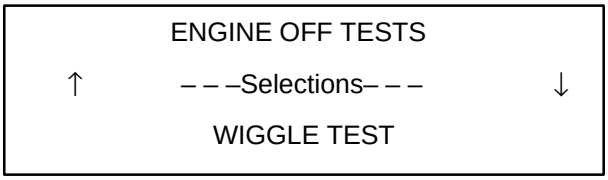
Record any faults found and refer to SECTION 5C - Electronic Control System Diagnostics.

Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

WIGGLE TEST

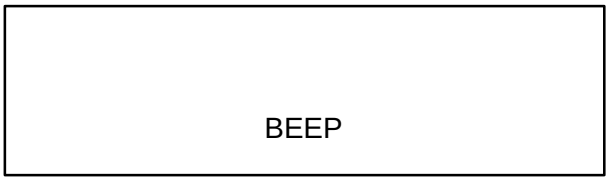
"WIGGLE TEST" is available under the DIAGNOSTIC TESTS Menu. The wiggle test is to assist the technician in finding an intermittent condition. The wiggle test will monitor both signal outputs and inputs **on a continuous** basis. Any interruption in the circuit will cause a fault.

To access "WIGGLE TEST" from the DIAGNOSTIC TESTS Menu, press "ENTER" under the selection "ENGINE OFF TESTS." Then press the "↓" key until "WIGGLE TEST" is displayed on the screen. Press the "ENTER" key, to start the test.

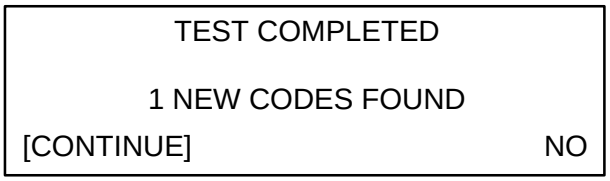


While in the Wiggle mode, the technician can move and wiggle the wiring harness and connectors to locate the problem.

At any time during the Wiggle Test if an open or short is detected the EST will beep and the word "BEEP" will display on the screen.



The screen will then show the number of fault codes found during the test. Press the "ENTER" key and the tool will show "TEST COMPLETED" and the number of codes found. It will ask if you wish to continue. Press "ENTER" and the EST will identify the fault codes found.



Press "ENTER" after the codes are displayed and the program will return to the ENGINE TESTS menu.

If any faults were detected, press the "ENTER" key to display the fault.

Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

OUTPUT STATE TEST

The next test available is the **"OUTPUT STATE TEST."** This will signal the ECM to energize the output circuits for testing.

There are two modes of operation during this test. The first is "OUTPUT ARE LOW" and the other is "OUTPUTS ARE HIGH."

When in the "OUTPUTS ARE LOW" mode the ECM will pull down the output voltage to ground. This will actuate the output components that are controlled by the ECM grounding the circuits. During this test "OUTPUTS ARE LOW" will be displayed on the screen.

When in the "OUTPUTS ARE HIGH" mode the ECM will pull up the output voltage to 12 volts. This will actuate the output components that are controlled by the ECM energizing the control circuits with 12 volts. During this test "OUTPUTS ARE HIGH" will be displayed on the screen.

During this test the following components will be exercised, Enable relay, IPR (Injection Pressure Regulator), ECI (Engine Crank Inhibit Relay), EDL (Engine Data Link Relay), relay and Check Engine lamp.

To access this test press the "↓" key until "OUTPUT STATE TEST" appears on the screen. Press **"ENTER"** to start the test.

Press the "ENTER" key to switch from "OUTPUTS ARE LOW" to "OUTPUTS ARE HIGH". The mode will change each time the **"ENTER"** key is pressed.

To end the test press the **"FUNC"** key.

While the test is being performed the technician can measure output circuits to be certain the ECM outputs are functioning properly.

Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

ENGINE RUNNING TEST

⚠ WARNING

If engine is to be tested with boat out of water, the propeller must be removed to avoid injury.

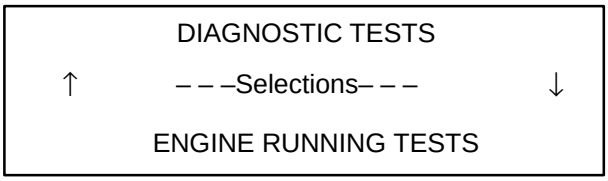
⚠ CAUTION

Avoid engine damage. Ensure that cooling water is supplied to the engine if it will be operated with the boat out of the water.

1. Start and run engine until it reaches 160° F (71° C) minimum.

NOTE: *Engine must be at least 160° F (71° C) to allow the ECM to perform an accurate test of the engine sensors and actuators. If engine coolant temperature is below self test range, the EST tool will display an "ECT Out Of Self Test Range" message.*

2. Access the "ENGINE RUNNING TEST" from the "DIAGNOSTIC TESTS" menu by pressing the "↓" key, until "ENGINE RUNNING TEST" appears on the screen. Then press the "ENTER" key.



The ECM will then conduct the "Engine Running Test." It will command the engine to accelerate to a pre-determined engine RPM and operate the Injection Pressure Regulator (IPR) valve.

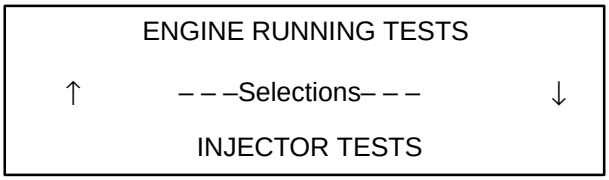
The ECM will measure the effects of actuator movement via the sensors. At the completion of the test, the EST screen will display "00 FAULTS", if no faults were detected. If EST indicates faults have been detected, press the "ENTER" key to display the fault codes. Record fault codes and refer to the Electronic Diagnostic form EGED–200 for fault codes which were detected.

Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

INJECTOR TEST (ENGINE RUNNING)

NOTE: *The "ENGINE RUNNING TEST - STANDARD TEST" must be performed first to access the injector test.*

After the "STANDARD TEST" has been completed, press the "↓" key from the "ENGINE RUNNING TEST" screen to access the "INJECTOR TEST." Then press the "ENTER" key.



NOTE: *The engine will run rough during the test.*

The Electronic Service Tool (EST) will signal the Electronic Control Module (ECM) to actuate each injector in a programmed sequence and then measure power cylinder performance.

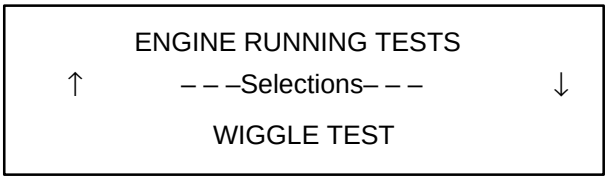
At the completion of the test, the EST screen will display "00 FAULTS," if no injector faults occurred. If EST indicates faults have been detected, press the "ENTER" key to display the fault codes. Record fault codes.

Electronic Service Tool (EST) - Pro-Link 9000 (Continued)

WIGGLE TEST

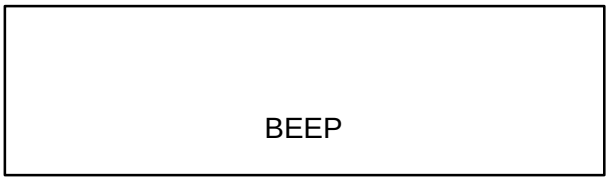
"WIGGLE TEST" is available under the DIAGNOSTIC TESTS Menu. The wiggle test is to assist the technician in finding an intermittent condition. The wiggle test will monitor both signal outputs and inputs **on a continuous** basis. Any interruption in the circuit will cause a fault.

To access "WIGGLE TEST" from the DIAGNOSTIC TESTS Menu, press "ENTER" under the selection "ENGINE RUNNING TESTS." Then press the "↓" key until "WIGGLE TEST" is displayed on the screen. Press the "ENTER" key, to start the test.

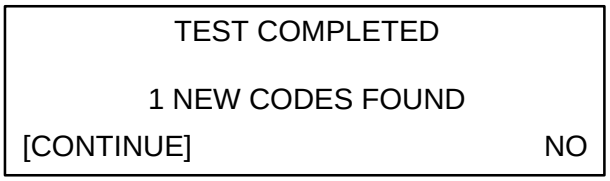


While in the Wiggle mode, the technician can move and wiggle the wiring harness and connectors to locate the problem.

At any time during the Wiggle Test if an open or short is detected the EST will beep and the word "BEEP" will display on the screen.



The screen will then show the number of fault codes found during the test. Press the "ENTER" key and the tool will show "TEST COMPLETED" and the number of codes found. It will ask if you wish to continue. Press "ENTER" and the EST will identify the fault codes found.



Press "ENTER" after the codes are displayed and the program will return to the ENGINE TESTS menu.

If any faults were detected, press the "ENTER" key to display the fault.

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FUEL SYSTEM

Section 5E - Fuel System Glossary

Table of Contents

Glossary 5E-3

5
E

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Glossary

Actuator - A device which performs work in response to an electrical signal.

Address - A specific memory location in the RAM, ROM, or KAM of the ECM. The ECM can either read information from an address or send information (write) to an address (RAM only).

Analog - A continuously variable voltage.

Analog to Digital Converter (A/D) - A circuit within the processing section of the ECM that takes an analog signal (either DC or AC) and converts it into a usable digital signal for the microprocessor.

Analog Multimeter - A meter that uses a needle to point to a number on a scale of numbers to indicate a measured value (volts, ohms, amperes). Not recommended for use on microprocessor systems because of the possibility of excessive current due to the low impedance of the meter.

ATA Data Link - A serial data link specified by the American Trucking Association and the SAE.

Background Manager - The portion of the computer that performs “housekeeping duties”. Typically the Background Manager controls low priority items or items that occur at a slower rate.

BARO Barometric Pressure Sensor - A variable capacitance sensor which, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal indicating pressure.

Calibration - The data values used by the strategy to solve equations and make decisions. Calibration values are stored in the ROM as scalars, functions and tables. Calibration values are input into the processor during programming to allow for the engine to operate within certain parameters.

CI, Cylinder identification - A signal from the ECM to the IDM that identifies the position of the cylinders of the engine.

Check Engine Lamp - Lamp in the dash that comes on when selected fault codes are set or when the ECM is utilizing FMEM strategy. Fault codes can be read as flash codes through the CHECK ENGINE lamp. To access the flash codes, the Audio Test switch toggle lever is pushed down and held while the ignition switch is placed in the “RUN” (ON) position to initiate an STI (Self Test Input “Engine Diagnostics”) test. This will cause the COOLANT TEMPERATURE lamp to flash any fault codes which were stored while operating the engine.

CLS, Coolant Level Switch - A switch style sensor used to indicate low coolant level. (Not present on Mercury MerCruiser products.)

CMP, Camshaft Position Sensor - A Hall effect sensor used to indicate engine speed and camshaft position. Speed is indicated by the number of vanes counted per revolution. Camshaft position is indicated by a single narrow vane which indicates #1 cylinder position or a wide vane in dual sync application that indicates #4 cylinder.

Continuous Test - A function of the ECM in which the inputs and outputs of the ECM are continuously monitored to assure that the readings are within set limits.

Disable - A type of computer decision which results in an system being deactivated and not allowed to operate.

Driver - A transistor in the output section of the ECM that is used to turn on or off various actuators in the system.

Duty Cycle Signal - A type of wave signal that has a controlled on/off time measure from 0% to 100%. Normally used to control solenoids.

DVOM Digital Volt Ohm Meter - A meter that uses a digital display to indicate a measured value. Preferred for use on microprocessor systems, because a DVOM has a very high internal impedance and will not load down the circuit being measured.

ECM, Electronic Control Module - The housing which contains the micro computer, V Ref regulator, input conditioners and output drivers.

ECM Power Relay - Relay which supplies or removes power to the ECM.

ECT, Engine Coolant Temperature Sensor - A thermistor type sensor which indicates engine temperature.

EFRC, Engine Family Rating Code - A code readable in the calibration list of the VPM with the EST service tool that identifies the horsepower and emission calibration of the engine.

Engine Off Test - A self test operation that is performed with the ignition switch in the ON position with the engine off.

Engine Running Test - Self test operation that is performed with the engine running.

EOP, Engine Oil Pressure sensor - A switch type sensor used to indicate low oil pressure.

EST Electronic Service Tool - The scan tool used for accessing diagnostics and programing the MerCruiser 7.3 D-Tronic electronic control system.

EWL - Engine Warning Light Circuit (Not present on Mercury MerCruiser products – are individual lamps. See Check Engine Lamp.)

FMEM, Failure Modes Effects Management - An alternate control strategy devised to reduce the adverse effects that can be caused by a system failure. Should a sensor fail, the ECM substitutes a good sensor signal or assumed sensor value in its place. The WARN ENGINE Lamp is then lit to alert the driver to take the engine in for service.

Foreground Manager - That portion of the computer that controls the primary engine control functions. The foreground manager responds to external events quickly to maintain correct engine performance under a variety of conditions. Typically the foreground manager controls high priority items.

Function - An input value to a computer which the computer solves for an output.

Fusible Link - A wire designed to melt if more than a specified amount of electrical current flows through it. (Not present on Mercury MerCruiser products.)

GPC, Glow Plug Control - Controls the current flow to the glow plugs. Glow plug relay ON time is controlled by the ECM and is a function of engine coolant temperature, barometric pressure and battery voltage. ON time normally varies between 10 to 120 seconds. The glow plug relay will only cycle on and off repeatedly when there is a voltage condition greater than 12.5 volts.

GPL - Glow Plug Wait Lamp

GPR, Glow Plug Relay - ECM controlled relay which supplies power to the glow plugs.

Hall Effect Sensor - A Hall Effect sensor generates a digital on/off signal that indicates speed and also engine timing. The signal is created by a switching action caused by the passing of a vanes thru a positive and negative voltage potential. When the vane is between this potential a signal is created. When the gap is between this potential is open, no signal is generated. The wider the vane the longer the duty cycle of the signal, the narrower the vane the shorter the duty cycle of the signal. A narrow vane is used to indicate the position of #1 cylinder and a wide vane to indicate the position of #4 cylinder. A Hall Effect sensor has three connections ground, Vref, signal.

High Speed Digital Inputs - Inputs to the ECM that are from a sensor that generates varying frequencies. Examples of high speed digital input sensors are engine speed, and Manifold Absolute Pressure (MAP) sensors.

IAT, Intake Air Temperature sensor - A thermistor style sensor used to indicate intake air temperature.

ICP, Injector Control Pressure Sensor - A transducer style sensor used to indicate Injection Control Pressure.

Impedance - A form of opposition to AC current flow measured in Ohms.

Injection Control Pressure - High lube oil pressure generated by a high pressure pump/pressure regulator used to hydraulically actuate the fuel injectors.

Input Conditioner - A device or circuit that conditions or prepares an input signal for use by the microprocessor.

IPR, Injection Control Pressure Regulator - An ECM controlled pulse width modulated regulator valve which regulates injection control oil pressure.

Low Speed Digital Inputs - Are switched sensor inputs that generate an on/off (high/low) signal to the ECM. The input supplied to the ECM from the sensor could be from a high input source switch (usually 12 or 5 volts) or could be from a grounding type switch which grounds the signal from a current limiting resistor internal to the ECM and creates a low signal. (0 volts)

MAP, Manifold Absolute Pressure - A MAP sensor is a sensor that generates a digital frequency that indicates manifold boost pressure or vacuum. The signal is created by switching action caused by manifold pressure on a diaphragm connected to a capacitor circuit in the sensor. The digital frequency increases as pressure increases. A MAP sensor has three connections, signal return (grd), MAP signal and V Ref.

Microprocessor - An integrated circuit within a micro computer which controls information flow within the computer.

Normally Closed - Refers to a switch or a solenoid that is closed when no control force is acting on it.

Normally Open - Refers to a switch or solenoid that is open when no control force is acting on it.

On Demand Test - A self test which the technician initiates, and is run from a program in the processor.

OCC, Output Circuit Check - An “On Demand” test performed during an “Engine Off” self test that tests the continuity of selected actuators.

Output State Check - A “On Demand” test selected by the technician which forces the processor to activate actuators “High or Low” for additional diagnostics.

OWL - Oil/Water Light and Alarm (Not present on Mercury MerCruiser products – are individual lamps.)

Potentiometer - Is an electro-mechanical device (variable voltage divider) which senses the position of a mechanical component. Potentiometers have three connections, Vref, Signal out (wiper) and ground.

PROM - Programmable Read Only Memory

Pulse Width - The length of time an actuator, such as an injector remains energized.

RAM, Random Access Memory - A type of memory that is used to store information. Information can be written to and read from the RAM. Input information such as current engine speed or temperature would be stored here to be compared to values stored in the ROM. All memory in the RAM is lost when the ignition switch is turned off.

Read - A computer operation where information is retrieved from the memory.

RFI - Radio Frequency Interference

ROM, Read Only Memory - A type of memory that is used to store information permanently. Information can not be written to the ROM memory. Operating strategies and calibration tables are the type of information most commonly stored in the ROM.

Sampling - The act of periodically collecting information, as from a sensor. A microprocessor samples inputs from various sensors in the process of controlling a system.

Scalar - A single numerical value that is assigned a label and is used as a calibration parameter. This value can be multiplied, divided, added or subtracted to a given input.

SIG GRD, Signal Ground - The common ground wire to the ECM in wire harness for the sensor inputs.

STI, Self Test Input "Engine Diagnostics" Switch - Diagnostic switch located on vessel dash used to activate Self Test Input engine diagnostics.

Strategy - A plan or set of operating instructions that the microprocessor follows in order to achieve a desired goal. Strategy is the computer program itself, including all equations and decision making logic. Strategy is always stored in the RAM an thus cannot be changed during calibration.

STOP - Stop Engine Lamp (Not present on Mercury MerCruiser products.)

Switch Sensors - Switch sensors are used to indicate position, levels or pressures. The signal of a switch sensor is a digital signal created by either the opening or closing a switch. The on or off signal can indicate position as in the case of a clutch switch, lever as in the case of a coolant level switch, or pressure as in the case of a low oil pressure switch. A switch sensor normally has two connections signal return (Grd) and the signal. A switch sensor is considered a low speed digital signal input.

Table - Devices that a computer uses to take two different inputs and solve for an output.

TAC, Tachometer Output Signal - Engine speed signal from the ECM. (Not used on Mercury MerCruiser products.)

Thermistor - Sensor used to determine temperature. A thermistor changes its resistance value in relation to temperature change. Increasing temperature results in decreasing resistance, decreasing temperature results in increasing resistance. The thermistor in conjunction with a current limiting resistor in the ECM forms a voltage divider that provides a voltage signal that indicates temperature. Since the top half of the voltage divider is the current limiting resistor and is internal to the ECM a thermistor sensor only has two connections, signal return and ground.

Threshold Value - A value stored in the ROM portion of the ECM. This value is compared to the value of a particular sensor provided to the ECM during the continuous self-test. If the value is not within the parameters of the threshold value, a service code is entered.

TPS, Throttle Position Sensor - A potentiometer style sensor that indicates the operator's throttle position.

Transducers (load cells) - Transducers are used to sense pressure. Their function is very similar to potentiometers. The 5 volt reference signal is changed by the internal circuitry of the sensor into an analog voltage that indicates pressure. A transducer sensor has three connections Vref, signal and ground.

Transition - Changing from one value or condition to another, such as from positive to negative in an electronic circuit.

UVC, Under Valve Cover - A combination valve cover gasket and harness containing fuel injector and glow plug wiring.

VIGN, Voltage Ignition - Voltage supplied by the ignition switch when the key is in the RUN (or ON) position.

V Ref Reference Voltage - A five volt reference supplied by the ECM to operate the engine sensors.

VBAT - Battery voltage. (See VPWR)

VPWR - Battery voltage. (See VBAT)

Write - A computer operation where information is sent to and stored in memory.

Abbreviations And Acronyms

ATS	AMBIENT TEMPERATURE SENSOR
BARO	BAROMETRIC PRESSURE SENSOR
CMP	CAMSHAFT POSITION SENSOR
ECM	ELECTRONIC CONTROL MODULE
ECT	ENGINE COOLANT TEMPERATURE SENSOR
EOP	ENGINE OIL PRESSURE SENSOR
FDCS	FUEL DELIVERY COMMAND SIGNAL
HEUI	HYDRAULICALLY ACTUATED, ELECTRONICALLY CONTROLLED UNIT INJECTORS
ICP	INJECTOR (OIL) CONTROL PRESSURE SENSOR
IDM	INJECTOR DRIVER MODULE
IPR	INJECTOR (OIL) PRESSURE REGULATOR
IDM	INJECTION DRIVE MODULE
MAP	MANIFOLD ABSOLUTE PRESSURE SENSOR
TPS	THROTTLE POSITION SENSOR
UVC	UNDER VALVE COVER
VOP	VALVE OPENING PRESSURE

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